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First Report on the Occurrence of Nannoplankton in Upper Cretaceous-Paleocene Sediments of Israel

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With 6 plates, 5 text-figures and 1 chart

Contents

Abstract

The present study brings first information on the occurrence of nannoplankton from Upper Cretaceous-Paleocene sediments of Israel.

The different stratigraphic units, i. e. Maastrichtian, Danian and Paleocene, are easily distinguished by their nannoplankton contents, and biostratigraphic correlations with other regions of the world are indicated.

Forty three species are listed and discussed.

Two subzones in the Upper Paleocene, based on different faunal assemblages are observed. The respective *Discoaster multiradiatus* communities of these subzones are discussed and statistically analyzed. A decrease in the number of the rays can be shown as a possible evolutionary trend within this species.

Introduction

Investigation of the calcareous nannoplankton has been going on for more than a century (EHRENBERG, 1836; HUXLEY, 1858). However, it is

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only recently that these tiny planktonic forms (2—30 μ) have attracted the marked attention of both marine biologists and paleontologists. The numerical importance of these nannofossils, increasing to enormous abundance in some marly and calcareous rocks of the Mesozoic and the Tertiary systems, was demonstrated by many workers (A. ARKHANGELSKY, M. BRAMLETTE, G. DEFLANDRE, K. GAARDER, E. KAMPTNER, E. MARTINI, D. NOËL, H. STRADNER, TAN SIN HOK and others). The wide geographic and in many cases the restricted stratigraphic distribution of the calcareous nannoplankton has already proved to be of importance in stratigraphical investigations, especially in the Upper Cretaceous and the Lower Tertiary (BRAMLETTE & SULLIVAN, 1961; BRAMLETTE & MARTINI, 1964; DEFLANDRE, 1959; HAY, 1961, 1962; MARTINI, 1961; STRADNER, 1963; STRADNER & PAPP, 1961; SULLIVAN, 1964, 1965).

It is true that due to the tiny size of these forms they are much more apt to be redeposited in younger strata, a fact that detracts somewhat from their stratigraphical value, but on the other hand this factor opens new scopes for research in other geological fields such as paleogeomorphology, paleocurrents etc. During the last years problems concerning paleoclimatology (COHEN, 1964) and paleoecology (SULLIVAN, 1964, 1965) have also been approached.

Recent studies of the morphological characters by means of the electron microscope proved to be a turning point in our knowledge of this group of nannofossils.

It was possible to show that even the smallest forms, of 2—3 μ or so, are in many cases quite complicated, and are too small to be resolved by the optical microscope. It is true that the general pattern of crystal arrangement can be discerned with polarized light but the shape of the individual crystals and their superposition could be established only through the high magnification of the electron microscope.

For quick determinations for stratigraphical purposes the optical microscope with its polarizing equipment doubtlessly remains the most valuable instrument, but for more comprehensive investigation both the electron and the optical microscopes must be employed.

The fossil assemblages discussed in this paper were obtained from Upper Cretaceous-Paleocene samples from Israel. The aim of this report is to record the nannoplankton species and discuss their known stratigraphic distribution.

Acknowledgement

The present investigation was carried out during a study term at the UNESCO-Course of the Post-Graduate Training Center for Geology, Vienna, under the direction of Prof. Dr. H. KÜPPER, the director of the Geological Survey of Austria, Vienna. A Fellowship was kindly granted by the Department of Education, the Austrian Government. The author is very much indebted to Dr. H. STRADNER of the Geol. Survey of Austria, Vienna, through whom he made his first acquaintance with this interesting group, for his supervision and advice throughout completion of this report.

The samples from the Safad area kindly supplied by Dr. A. FLEXER, the Hebrew University of Jerusalem, Israel. Part of his columnar section No. 1 of this area is reproduced (Fig. 2). Samples from other localities were supplied by the Geol. Survey of Israel, Ministry of Development, Jerusalem, mostly collected by Y. ARKIN & A. STARINSKY of the Mapping Division. They are also authors of the schematic sections (Figs. 3, 4) of the Paleocene. Age determinations of all the Geol. Survey Israel samples were made by Dr. Z. REISS of the Paleontology Division, on the basis of foraminifera. Mr. T. TAKAYAMA, Inst. Geol. Paleont., Tohoku University, Japan, supplied helpful general information. Mrs. I. ZAK of the Geol. Survey of Austria, Vienna, assisted the author with the arrangement of the plates. Mr. I. PERATH of the Israel National Oil Co. read and corrected some parts of the English manuscript.

The kind help of alle these persons is gratefully acknowledged.

Methods of Study

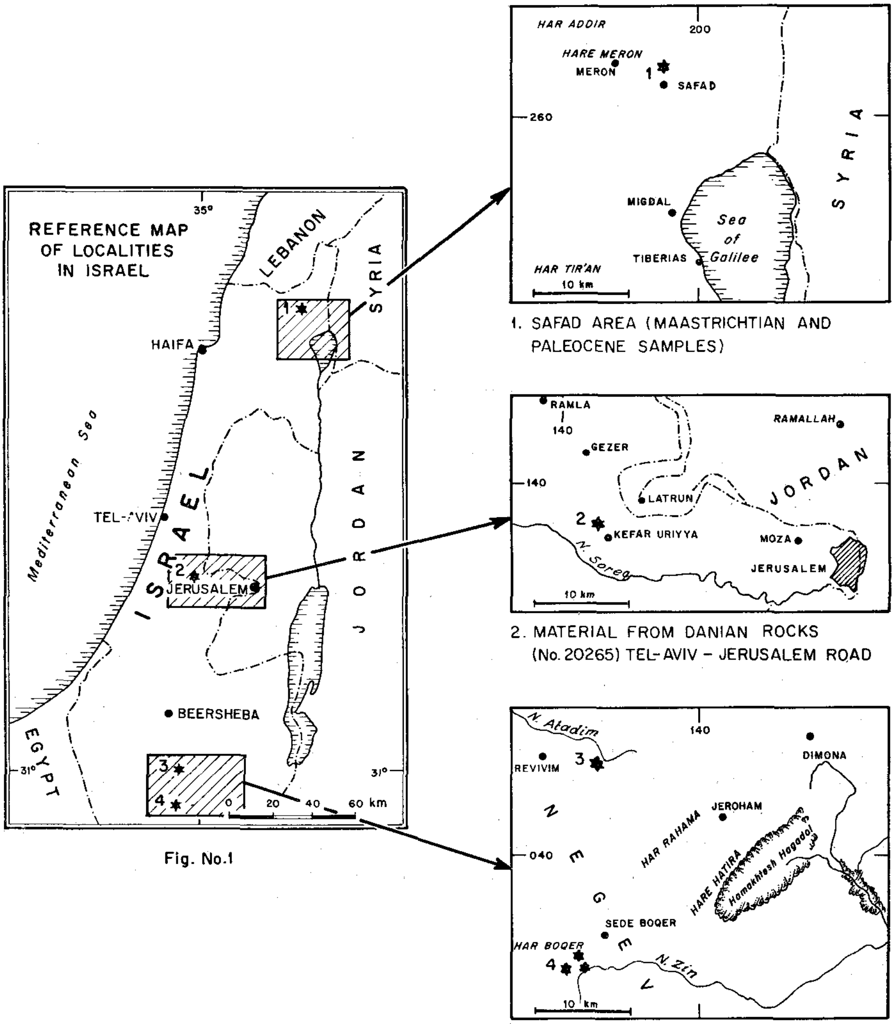
The samples were treated and examined according to the methods outlined by STRADNER & PAPP (1961) and COHEN (1964). A Reichert binocular polarizing microscope BIOZET was used, with oil-immersion magnification of 1000x. The microphotographs were taken with an EXAKTA Camera. For obtaining better relief when dealing with discoasterids, the author followed STRADNER's (1963) method. In some cases, however, depending on the preservation conditions of the samples, a medium of castor oil ($n = 1.48$) was used instead of saturated $CaCl_2$ ($n = 1.47$). For the study of coccoliths, Caedax ($n = 1.55$) or Canada balsam ($n = 1.54$) were used, sometimes mixed with xylene (BRAMLETTE & SULLIVAN, 1961). When using media other than Caedax or Canada balsam, the edges of the cover glass were glued to the slide by Konstruvit Geistlich.

A simple statistical method was used for finding the relationship between two different **Discoaster multiradiatus** communities occurring in adjacent biostratigraphic subzones in the Upper Paleocene. In this case the diameter and the number of rays of the individual specimens were measured and counted. Results are shown in Fig. 5.

Stratigraphical and Paleontological Relations of the Studied Material

Safad Area

Outcrops in this area, which is situated in Upper Galilee, north Israel (see reference map, Fig. 1), consist mainly of Upper Cretaceous-Eocene rocks. The area was geologically mapped by SHIFTAN (1952) and by FLEXER (1964). The latter author also made a detailed paleogeographical study of this area (unpublished Ph. D. thesis, The Hebrew Univ. Jerusalem, 1964). The material for the present nannoplankton study was taken from FLEXER's samples, represented in his Columnar Section No. 1 of the above work, and which, on the basis of foraminifera, had been assigned to Turonian-Paleocene. In



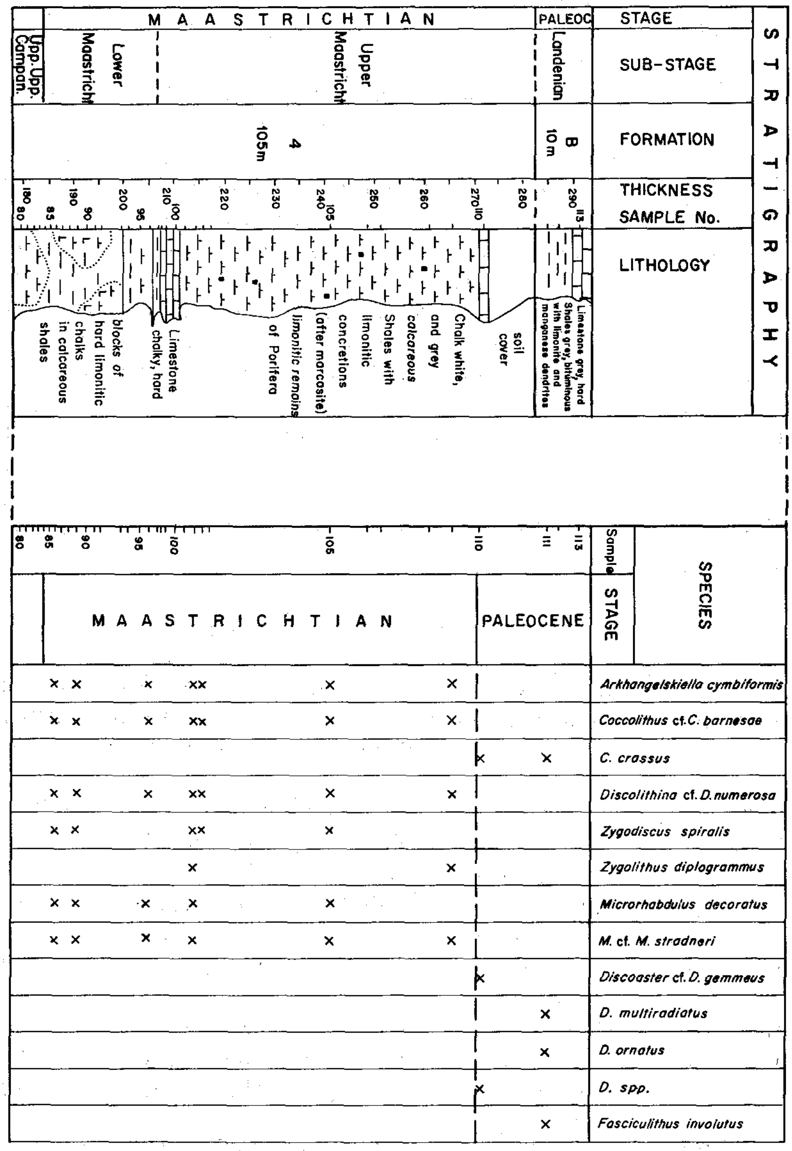
1. SAFAD AREA (MAASTRICHTIAN AND PALEOCENE SAMPLES)

2. MATERIAL FROM DANIAN ROCKS (No. 20265) TEL-AVIV – JERUSALEM ROAD

3. NAHAL ATADIM -(PALEOCENE SAMPLES)
4. NAHAL ZIN (MAASTRICHTIAN AND PALEOCENE SAMPLES)

Fig. No.1

the present report the author has restricted himself to the study of the Maastrichtian — Paleocene samples. Most of the 11 supplied samples contained large amounts of nannoplankton, but usually their state of preservation was not good enough for a thorough study and description, and therefore a few samples only were treated more thoroughly.



PART OF SECTION No. 1 SAFAD ISRAEL.
(REPRODUCED FROM A. FLEXER'S WORK (1964)

Fig. No. 2

DISTRIBUTION OF SOME CHARACTERISTIC NANNOFOSSILS IN THE SAMPLES OF SECTION No. 1, SAFAD (FOR DETAILS REFER TABLE No. 1)

According to FLEXER the Maastrichtian-Paleocene section consists of white and limonitic chalks, calcareous shales and limestones. The Maastrichtian rocks, reaching a thickness of about 100 m., are overlain by Paleocene rocks of Landenian age composed of limestones and hard shales with bituminous and limonitic material. According to FLEXER their thickness reaches about 10 m. and the contact between the Maastrichtian and the Paleocene is found just above the soil cover. The following foraminiferal species were found in the Maastrichtian: *Neoflabellina numismalis-efferata, Praebulimina kickapooensis, Angulogavelinella abudurbensis, Reusella pseudospinulosa, Bolivinoides draco miliaris, B. draco draco, B. draco dorreeni, Globotruncana gagnebini, G. esnehensis, Praebulimina laevis, P. arkadelphiana, Cibicides voltziana, C. beaumontiana, Bolivina incrassata* "gigantea", *Anomalinoides rubiginosa, A. pseudoacuta, A. constricta, Allomorphina conica, Stensioina pommerana, Gyroidinoides naranjoensis* etc. The Paleocene (Landenian) contains: *Gyroidinoides naranjoensis Anomalinoides vanbelleni, Angulogavelinella* "danica", *Loxostomoides applinae, Truncorotalia angulata, Bulimina midwayensis.*

According to the results obtained by nannoplankton from this section (Fig. 2), it is clear that the boundary between the Maastrichtian and the Paleocene is to be found immediately below the soil cover, so that the hard limestone (Sample S-110) must be already assigned to the Paleocene. Indeed, no indicative microfauna was found in this sample (FLEXER, 1964), and according to recent personal communication the author confirms that this sample contains in fact a somewhat different foraminiferal assemblage than those of the Maastrichtian and could be already related to the Danian-Paleocene.

Other localities

Of the many outcrop samples supplied by the Geological Survey of Israel, only the marly specimens were treated owing to the relatively better preservation of their nannofossil contents. They include:

Sample	Age	Locality	Coordinates
A. S. 229	Paleocene (Landenian)	Nahal Atadim, The Negev (Southern Israel)	1295/0498
Y. A. 45	Paleocene (Landenian)	Nahal Zin, The Negev	1289/0278
Y. A. 35	Paleocene (Landenian)	Nahal Zin, The Negev	1270/0275
No. 20265	Danian	Tel Aviv—Jerusalem Rd.	144/135
Y. A. 84	Maastrichtian	Nahal Zin, The Negev	1282/0289
Y. A. 74	Maastrichtian	Nahal Zin, The Negev	1282/0289

Sample A. S. 229 was taken from a higher stratigraphical level than Y. A. 35 and Y. A. 45 (see Figs. 3 and 4). This is also confirmed in the results. All three samples are of Upper Paleocene (Landenian) age and belong to the Hafir Member which occurs in the higher part of the Taqiye Formation (see Lexique Stratig. Internat. Vol. III, fasc. 10 C 2, Israel, 1960).

The ages were determined on the basis of foraminifera, by Dr. Z. Reiss of the Geol. Surv. Israel. The Maastrichtian samples contain, among others: *Bolivinoides draco draco, Praebulimina laevis, Bolivina incrassata, Stensioina pommerana, Globotruncana contusa, G. gansseri, G. esnehensis, Racemiguembelina* spp., *Neoflabellina reticulata, Pseudotextularia* spp., *Pseudoguembelina* spp., *Rugoglobigerina* spp.

The Danian sample contains among others: *Globoconusa daubjergensis, Globigerina (Subbotina) triloculinoides, G. (S.) pseudobulloides, Globorotalia (Turborotalia) compressa, Angulogavelinella avnimelechi, Alabamina midwayensis, Bolivina midwayensis, Pseudoclavulina globulifera, Spiroplectammina plummerae, Tappanina selmensis, Bolivinoides delicatula* etc.

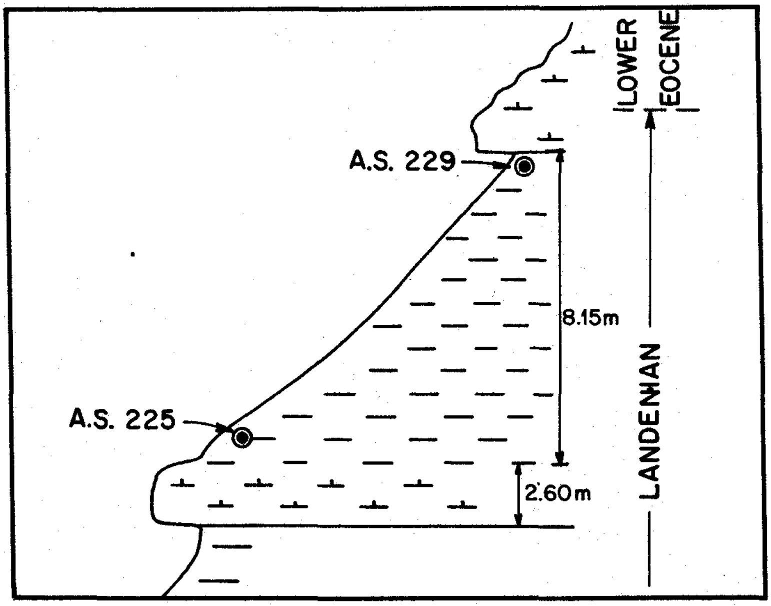


Fig. No. 3

SCHEMATIC CROSS-SECTION AND LOCATIONS OF UPPER PALEOCENE (LANDENIAN) SAMPLES A.S. 225 & A.S. 229 (No. 3 IN REFERENCE MAP. COORD. 1295/0498)

CHALK MARL

The Upper Paleocene (Landenian) samples contain among others: *Globorotalia angulata, G. simulatilis, G. pseudomendardii, G. velascoensis, G. aequa, Siphogaudryina aissana, Bolivinoides curtus, Angulogavelinella avnimelechi* etc.

According to the nannoplankton, the different stratigraphic levels were easily observed. Furthermore, two biostratigraphic subzones in the Upper Paleocene can be distinguished. These subzones are based on different faunal assemblages and also on different characteristics of *Discoaster multiradiatus.*

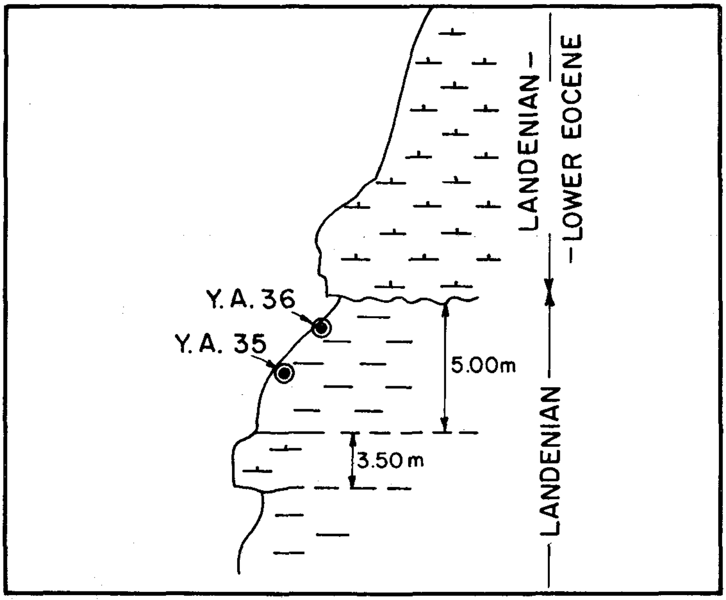


Fig. No. 4

SCHEMATIC CROSS-SECTION AND LOCATION OF UPPER PALEOCENE (LANDENIAN) SAMPLES Y.A.35 & Y.A.36. (No. 4 IN REFERENCE MAP. COORD. 1270/0275.)

CHALK MARL

Correlation and Age Assignment of the Nannoplankton

Chart 1 summarizes the vertical distribution of the calcareous nannoplankton species recorded in the present paper. It does not, however, indicate redeposited specimens, full findings of which are already mentioned in the text and in the chapter of systematic paleontology. From this chart it is seen that the three stages, i. e. Maastrichtian, Danian and the Paleocene differ from each other by their faunal assemblages and are easily distinguishable. The most diversified assemblage is that of the Maastrichtian. This fact is in good accordance with the results of BRAMLETTE & MARTINI (1964) and STRADNER (1963). The following forms were recorded:

Arkhangelskiella cymbiformis VEKSHINA
Coccolithus cf. *C. barnesae* (BLACK)
Zygodiscus? amphipons BRAMLETTE & MARTINI
Discolithina cf. *D. numerosa* (GORKA)
Deflandrius intercisus (DEFLANDRE)
Kamptnerius magnificus DEFLANDRE
Parhabdolithus embergeri (NOËL)
Zygodiscus spiralis BRAMLETTE & MARTINI
Zygolithus diplogrammus DEFLANDRE
Z. chelmiensis GORKA
Z. crux (DEFLANDRE & FERT)
Eiffellithus turriseiffeli (DEFLANDRE)
Braarudosphaera bigelowi (GRAN & BRAARUD)
Thoracosphaera cf. *T. imperforata* KAMPTNER
Cylindralithus cf. *C. serratus* BRAMLETTE & MARTINI
Lithraphidites carniolensis DEFLANDRE
Lucianorhabdus cayeuxi DEFLANDRE
Microrhabdulus decoratus DEFLANDRE
M. cf. *M. stradneri* BRAMLETTE & MARTINI
Micula staurophora (GARDET)
Tetralithus gothicus form. *trifida* STRADNER
Cretarhabdus decorus (DEFLANDRE)

No important differences in species were noted between the Maastrichtian samples from northern Israel (Safad area) and those from southern Israel (The Negev), and the distribution of the species was about the same.

According to BRAMLETTE & MARTINI (1964) and STRADNER (1963) most of these forms appear already before the Maastrichtian and are known throughout most of the Senonian. Their exact distribution awaits further study. Some of the most typical forms encountered regularly in the Maastrichtian samples described here are:

Micula staurophora, Arkhangelskiella cymbiformis, Coccolithus cf. *C. barnesae, Zygolithus diplogrammus, Lithraphidites carniolensis, Microrhabdulus decoratus, Discolithina* cf. *D. numerosa, Eiffellithus turriseiffeli.*

The forms found in the Maastrichtian samples of Israel have been registered in equivalent stratigraphic levels in different parts of the world (U. S. A., Europe, North Africa, U. S. S. R., Poland etc.) by BRAMLETTE & MARTINI (1964), DEFLANDRE (1959), GORKA (1957, 1963), STRADNER (1963) and VEKSHINA (1959).

A sharp boundary between the nannoplankton faunas of the Maastrichtian and the Danian was already noted by BRAMLETTE (1958), BRAMLETTE & MARTINI (1964) and STRADNER (1963). The rich and diversified faunal association of the Maastrichtian suddenly changes to an entirely different meagre community with only few dominant forms, such as *Coccolithus* *helis* STRADNER, *C. crassus* BRAMLETTE & SULLIVAN, *Zygolithus concinnus* MARTINI, *Zygodiscus sigmoides* BRAMLETTE & SULLIVAN and some others.

This remarkable phenomenon is also noted in the Danian sample from Israel. Though only one sample of Danian rock was available to the author in the present report, it was enough to show the big difference from the older Maastrichtian assemblages. This seems to be in accordance with a similar foraminiferal brake in this country already marked by REISS (1955).

The prevailing Danian forms in Sample 20265, from the central part of the country, are:

Zygodiscus sigmoides BRAMLETTE & SULLIVAN
Z. concinnus MARTINI
Coccolithus helis STRADNER
C. danicus (BROTZEN)
C. crassus BRAMLETTE & SULLIVAN
Thoracosphaera cf. *T. imperforata* KAMPTNER
T. cf. *T. deflandrei* KAMPTNER

All these forms are unknown in older geological formations (except for *Thoracosphaera* spp.) and appear for the first time in Danian sediments. Some rare occurrences of redeposited Maastrichtian forms, such as *Micula staurophora, Arkhangelskiella cymbiformis, Deflandrius intercisus,* were noted, but on the whole the change is very evident and easily recognized. The general appearance of the coccoliths is already that of the Lower Tertiary forms, and is quite different from the Upper Cretaceous forms. They are reported in Danian rocks from Europe and the U. S. A. (BRAMLETTE & MARTINI, 1964; BROTZEN, 1959; MARTINI, 1964; STRADNER, 1963).

A turning event seems to have taken place in the evolution of the calcareous nannoplankton during the Paleocene, with a sudden explosion of a new group — the Discoasterids. These star-shaped forms, whose taxonomic position is still undetermined, are owing to their bigger size and simpler construction, much easier to study when compared with the coccoliths.

Five samples from Paleocene rocks were examined. Sample S-110 from the Safad area, regarded by FLEXER (1964) as uppermost Maastrichtian, yielded among others the following forms:

Coccolithus crassus BRAMLETTE & SULLIVAN
Braarudosphaera bigelowi (GRAN & BRAARUD)
Discoaster cf. *D. gemmeus* STRADNER
Discoaster spp.

Preservation of this sample is relatively bad and no definite determination of other species was possible. According to present knowledge *Coccolithus crassus* appears for the first time in the Danian, whereas *Discoaster gemmeus* is known from the Middle to Upper Paleocene. The presence of Discoasterids in this sample excludes the possibility of Maastrichtian age of this sample and points to a Middle — Upper Paleocene age. Figure 2 represents part of FLEXER's columnar section of the Safad area. According to the above results the boundary between the Maastrichtian and the Paleocene has been moved downward by about 10 m. as shown on the right-hand diagram of Fig. 2.

Sample S-111 of the above section, some 15 m. above the previous sample, yielded already the Upper Paleocene fossils:

Discoaster diastypus BRAMLETTE & SULLIVAN
D. delicatus BRAMLETTE & SULLIVAN
D. ornatus STRADNER
D. multiradiatus BRAMLETTE & RIEDEL
Fasciculithus involutus BRAMLETTE & SULLIVAN
Coccolithus crassus BRAMLETTE & SULLIVAN
C. bidens BRAMLETTE & SULLIVAN

Of special importance is the presence of *D. multiradiatus*. This species, which was described for the first time from the Paleocene, Velasco-shale, Mexico, has been reported meanwhile by different authors from various parts of the world in upper Paleocene strata.

A similar faunal assemblage is found also in the Landenian samples (Y.A. 35 and Y.A. 45) of the southern part of the country (Fig. 4). Among other species they contain:

Coccolithus bidens BRAMLETTE & SULLIVAN
Discoaster diastypus BRAMLETTE & SULLIVAN
D. ehrenbergi TAN SIN HOK
D. multiradiatus BRAMLETTE & RIEDEL
Fasciculithus involutus BRAMLETTE & SULLIVAN

Sample A. S. 229, also of Landenian age from a somewhat higher stratigraphic level (Fig. 3), bears a different faunal assemblage, and *Discoaster multiradiatus* is found to be associated with *Marthasterites bramlettei* BRÖNNIMANN & STRADNER, *M. contortus* (STRADNER) and *M. robustus* (STRADNER), which are lacking in the other Landenian samples (Y. A. 35; Y. A. 45; S-110; S-111).

HAY (1961, 1962) in his works on the Discoasterids of the Schlierenflysh of Switzerland, already suggested that the zone with *Discoaster multiradiatus* which characterizes the base of the Schonisandstein, could be subdivided into two subzones: a lower — *D. multiradiatus* subzone in which the latter species predominates, and a higher — *Marthasterites contortus* subzone which is distinguished by the first appearance of this species and of *M. bramlettei*. According to our results, it seems that these subzones of the Landenian are present at least in part of Israel.

A further study of the *D. multiradiatus* communities that appear in these subzones was attempted by a statistical method. In each subzone a hundred specimens of *D. multiradiatus* were measured, and their rays were counted.

The results clearly demonstrate a reduction in the number of rays in the individuals of the upper subzone. It is possible that this tendency is the expression of an evolutionary trend, in which case it may be used as a criterion for recognizing redeposited material; however ecological reasons must be considered as well before reaching definite conclusions.

Systematic Paleontology

FAMILY COCCOLITHOPHORIDAE Lohmann

Genus *Arkhangelskiella* Vekshina, 1959, emend. Bramlette & Martini

Arkhangelskiella cymbiformis Vekshina

(Pl. 1, figures 6, 6 a, 7, 8; pl. 5, figures 1, 2 a, 2 b)

1912 "Coccolith of unknown affinities" — Arkhangelsky, Material zur Geol. Russlands, vol. 25, pl. 6, fig. 24.
1959 *Arkhangelskiella cymbiformis* Vekshina — Sibir. Nauchn. Issled. Inst. Geol. Geof. Syriya, Trudy, no. 2, p. 66, pl. 2, figs. 3 a—b.
1963 *Arkhangelskiella cymbiformis* Vekshina — Stradner, Sixth World Petrol. Congress Frankfurt, Sect. 1, paper 4 (preprint), p. 12, pl. 1, figs. 4 a—c.
1964 *Arkhangelskiella cymbiformis* Vekshina — Bramlette & Martini, Micropal., vol. 10, no. 3, p. 297, pl. 1, figs. 3—9.

R e m a r k s: This form is easily distinguishable by its central part with the straight cross and the minute perforations, especially when observed between cross nicols.

D i s t r i b u t i o n: Though not so frequent, this form is found in all the examined samples of Safad area and the Negev, (S-86; S-89; S-96; S-102; S-103; S-105; S-109; Y. A. 74; Y. A. 84) of Maastrichtian age. Some rare reworked specimens were found also in the Danian and the upper Paleocene samples. According to different authors this species is typical in the Maastrichtian and in equivalents in many countries (Denmark; France; Austria; U. S. S. R.; Tunesia; U. S. A.).

Genus *Coccolithus* Schwarz, 1894

Coccolithus cf. *C. barnesae* (Black)

1964 *Coccolithus* cf. *C. barnesae* (Black) — Bramlette & Martini, Micropal., vol. 10, no. 3, p. 298, pl. 1, figs. 13—14.

R e m a r k s: Our specimens are similar to the one figured by Bramette & Martini (1964). This form is very much pronounced between cross nicols, however, it seems that further study of its elements with the electron microscope is indispensible.

D i s t r i b u t i o n: Very typical in the Maastrichtian samples of Safad area (S-86, S-89, S-96, S-102, S-103, S-105, S-109) and the Negev (Y. A. 74).

Coccolithus bidens BRAMLETTE & SULLIVAN

(Pl. 2, figure 4; pl. 5, figure 13)

1961 *Coccolithus bidens* BRAMLETTE & SULLIVAN — Micropal., vol. 7, no. 2, p. 139, pl. 1, fig. 1.
1963 *Coccolithus bidens* BRAMLETTE & SULLIVAN — STRADNER (in: GOHRBANDT), Mitt. Geol. Ges., Wien, Bd. 56, H. 1, p. 72, pl. 8, figs. 1—2.
1964 *Coccolithus bidens* BRAMLETTE & SULLIVAN — SULLIVAN, Univ. California Publ., Geol. Sci., vol. 44, no. 3, p. 180, pl. 1, figs. 10 a—b.

R e m a r k s: The small projections into the central opening were not observed, but this may be due to bad preservation of the sample.

D i s t r i b u t i o n: Upper Paleocene (Landenian) sample from Safad area (S-111) and the Negev (Y. A. 35). Known from Paleocene rocks of the U. S. A. (Lodo Formation-Unit 1; Anita Shale), Austria (Südhelvetikum zone north of Salzburg, zone E — Ilerdian, and zone F — Cuisian), England (in the type Thanetian) and in S.W. France.

Coccolithus crassus BRAMLETTE & SULLIVAN

(Pl. 5, figure 9 a, 9 b)

1961 *Coccolithus crassus* BRAMLETTE & SULLIVAN — Micropal., vol. 7, no. 2, p. 139, pl. 1, figs. 4 a—d.
1963 *Coccolithus crassus* BRAMLETTE & SULLIVAN — STRADNER (in: GOHRBANDT), Mitt. Geol. Ges., Wien, Bd. 56, H. 1, pl. 8, figs. 13—15.
1964 *Coccolithus crassus* BRAMLETTE & SULLIVAN — SULLIVAN, Univ. California Publ., Geol. Sci., vol. 44, no. 3, p. 180, pl. 3, figs. 4 a—b.

R e m a r k s : The central area of this form is very conspicuous between cross nicols, whereas the thin margins of the larger plate are indistinct.

D i s t r i b u t i o n : Common in the Danian sample (20265) and in the upper Paleocene (S-110, S-111, Y. A. 45, A. S. 229) of Israel. STRADNER (in GOHRBANDT, 1963) found it in the Danian and throughout the Paleocene in the Südhelvetikum north of Salzburg, Austria. Originally, it was described from the Lodo Formation (Unit 3 — Lower Eocene, and Unit 4 — Middle Eocene), California. It is known also from the Lutetian, Donzacq, France.

Coccolithus danicus (BROTZEN)

(Pl. 2, figure 2)

1959 *Cribrosphaerella danica* BROTZEN — Sver. Geol. Undersök, ser. C, no. 571, p. 25, text-fig. 9 (no. 4—6).
1964 *Coccolithus danicus* (BROTZEN) — BRAMLETTE & MARTINI, Micropal., vol. 10, no. 3, p. 298, pl. 1, figs. 15—16.

1964 *Coccolithus danicus* (BROTZEN) — MARTINI, N. Jb. Geol. Paläont. Abh., vol. 121, no. 1, p. 48, pl. 6, figs. 3—4.

Remarks: These forms with the oblique cross show similarities with those of the Paleocene and the Eocene (*C. bidens* and *C. grandis* BRAMLETTE & RIEDEL) but differ in details; the Danian forms being usually smaller. The original microphotographic descriptions of BROTZEN (1959, figs. 1—3; 7—8) are vague, however, figs. 4—6 and especially the descriptions of BRAMLETTE & MARTINI (1964) resemble our specimens.

Distribution: Rare in the Danian sample (20265) from central Israel. This form is known in the Upper Danian of Sweden, the type Danian and in equivalents in S.W. France, Tunisia and Alabama (Clayton Formation).

Coccolithus helis STRADNER

(Pl. 2, figure 1, pl. 5, figure 11)

1961 *Heliorthus tenuis* STRADNER — Erdoelzeitschr., vol. 77, p. 84, text-fig. 64—65.
1963 *Coccolithus helis* STRADNER — (in: GOHRBANDT), Mitt. Geol. Ges., Wien, Bd. 56, H. 1, p. 74, pl. 8, fig. 16; pl. 9, figs. 1—2.
1964 *Coccolithus helis* STRADNER — BRAMLETTE & MARTINI, Micropal., vol. 10, no. 3, p. 298, pl. 1, figs. 10—12.
1964 *Coccolithus helis* STRADNER — MARTINI, N. Jb. Geol. Paläont. Abh., vol. 121, no. 1, p. 48, pl. 6, figs. 5—6.

Remarks: Our specimens agree with the descriptions of the above authors. This species seems to be related to the group of *C. staurion* BRAMLETTE & SULLIVAN of the Middle Eocene. The latter is however bigger in size while its crossed central area is smaller.

Distribution: Present in the Danian sample (20265) of central Israel, where it is more common than *C. danicus*. The species is known in the type Danian and its equivalents in Austria, S.W. France, Tunesia and in the U. S. A. (Alabama, Clayton Formation).

Genus *Cretarhabdus* BBRAMLETTE & MARTINI, 1964

Cretarhabdus decorus (DEFLANDRE)

1954 *Rhabdolithus decorus* DEFLANDRE — (in: DEFLANDRE & FERT), Ann. Pal., vol. 40, p. 159, pl. 13, figs. 4—6, text-fig. 87.
1964 *Cretarhabdus decorus* (DEFLANDRE) — BRAMLETTE & MARTINI, Micropal., vol. 10, no. 3, p. 300, pl. 3, figs. 9—12.

Distribution: Found in the Maastrichtian samples of Safad (S-102) and the Negev (Y. A. 84). Recorded in the Maastrichtian rocks in S.W. France, Siberia, Tunisia and in the U. S. A. (BBRAMLETTE & MARTINI, 1964). DEFLANDRE (in DEFLANDRE & FERT, 1954), described it from evidently reworked material in the Lower Lutetian of Donzacq, France.

Genus *Deflandrius* BRAMLETTE & MARTINI, 1964
Deflandrius intercisus (DEFLANDRE)
(Pl. 1, figure 18)

1954 *Rhabdolithus intercisus* DEFLANDRE — (in: DEFLANDRE & FERT), Ann. Pal., vol. 40, p. 159, pl. 13, figs. 12—13; text-figs. 91—92.
1959 *Zygrhablithus intercisus* (DEFLANDRE) — DEFLANDRE, Rev. Micropal., vol. 2, p. 136, pl. 1, figs. 5—20.
1964 *Deflandrius intercisus* (DEFLANDRE) — BRAMLETTE & MARTINI, Micropal., vol. 10, no. 3, p. 301, pl. 2, figs. 13—16.

Remarks: This form is easily distinguishable in apical view by its diagonal crossbars and the peripheral 16—18 knobs. Dimensions: Length 10—13μ.

Distribution: Common in the Maastrichtian of Safad area (S-86, S-105) and the Negev (Y. A. 74, Y. A. 84). Known in the type Maastrichtian and equivalents in Denmark, France, Tunisia and the U. S. A. Originally recorded by DEFLANDRE from the Campanian of the Basses-Pyrénées, France.

Genus *Discolithina* LOEBLICH & TAPPAN, 1963
Discolithina cf. *D. numerosa* (GORKA)
(Pl. 1, figures 2, 2 a, 3—5; pl. 5, figure 4)

1957 *Discolithus numerosus* GORKA — Acta Pal. Polonica, vol. 2, p. 257, pl. 4, fig. 5.
1964 *Discolithina?* cf. *D. numerosa* (GORKA) — BRAMLETTE & MARTINI, Micropal., vol. 10, no. 3, p. 301, pl. 1, figs. 23—24.

Remarks: All the checked specimens show only one plate in side view. A range of variations in the form is noted. The general outlines is usually elliptical but sometimes it is nearly triangular. Some have smooth margins while many others bear radial striations.

Distribution: This form is very typical and occurs in all the studied Maastrichtian samples from Safad area and the Negev. Some rare specimens were found also in the Danian Sample (20265) from central Israel and in the Upper Paleocene of Safad (S-111).

Found in the type Maastrichtian and common in Maastrichtian equivalents in Denmark, France, Tunisia, U. S. A. and Poland (BRAMLETTE & MARTINI, 1964).

Genus *Parhabdolithus* DEFLANDRE, 1952
Parhabdolithus embergeri (NOËL)
(Pl. 1, figures 15, 16)

1958 *Discolithus embergeri* NOËL — Publ. Serv. Carte Geol. Algérie, Bull. 20, p. 164, pl. 1, figs. 5—8.
1963 *Parhabdolithus embergeri* (NOËL) — STRADNER, Sixth World Petr. Congress, Frankfurt, Sect. 1, paper 4 (preprint), pl. 4, fig. 1.

R e m a r k s: The general features are much the same as described by the author, though the forms found in the Maastrichtian samples are smaller. Dimensions: Lenght 14—20 μ.

D i s t r i b u t i o n: Maastrichtian of Safad area (S-96) and the Negev (Y. A. 74). Originally described from the Portlandian, Berriasian and Valanginian of Alger.

Genus *Kamptnerius* DEFLANDRE, 1959

Kamptnerius magnificus DEFLANDRE

(Pl. 5, figure 5)

1959 *Kamptnerius magnificus* DEFLANDRE — Rev. Micropal., vol. 2, p. 135, pl. 1, figs. 1—4.
1963 *Kamptnerius magnificus* DEFLANDRE — GORKA, Acta Pal. Polonica, vol. 8, no. 1, p. 16, text-pl. 3, figs. 1—3.
1964 *Kamptnerius magnificus* DEFLANDRE — BRAMLETTE & MARTINI, Micropal., vol. 10, no. 3, p. 301, pl. 2, figs. 1—2.

R e m a r k s: Our specimen resembles especially figures 1—2 of BRAMLETTE & MARTINI (1964) which they regard as a variant owing to the exceptional assymetry in the flange.

D i s t r i b u t i o n: Rare in the Maastrichtian sample (Y. A. 74) of the Negev. Known from the Maastrichtian of France, Denmark, Tunisia, U. S. A., Poland, the upper Campanian of Poland, the Santonian of Texas and the Cretaceous of Australia. Originally recorded from the Maastrichtian of France.

Genus *Zygodiscus* BRAMLETTE & SULLIVAN, 1961

Zygodiscus? amphipons BRAMLETTE & MARTINI

(Pl. 1, figures 9, 10)

1964 *Zygodiscus? amphipons* BRAMLETTE & MARTINI — Micropal., vol. 10, no. 3, p. 302, pl. 4, figs. 9—10.

R e m a r k s: A small form (Length 5—10 μ) which generally agrees with the descriptions of the authors, however, further electron microscopic examinations are needed for the study of this small form.

D i s t r i b u t i o n: In the Maastrichtian samples of Safad area (S-103, S-105) and the Negev (V. A. 74).

Zygodiscus sigmoides BRAMLETTE & SULLIVAN

(Pl. 2, figure 5)

1961 *Zygodiscus sigmoides* BRAMLETTE & SULLIVAN — Micropal., vol. 7, p. 149, pl. 4, figs. 11 a—e.
1961 *Zygrhablithus simplex* BRAMLETTE & SULLIVAN — Ibid., p. 151, pl. 6, figs. 19—22.

1964 *Zygodiscus sigmoides* BRAMLETTE & SULLIVAN — BRAMLETTE & MARTINI, Micropal., vol. 10, no. 3, p. 303, pl. 4, figs. 3—5.
1964 *Zygodiscus sigmoides* BRAMLETTE & SULLIVAN — MARTINI, N. Jb. Geol. Paläont. Abh., vol. 121, no. 1, p. 50, pl. 6, figs. 11—12.

Remarks: *Z. simplex* seems to be identical with *Z. sigmoides* (see BRAMLETTE & MARTINI, 1964; MARTINI, 1964). Our specimens which are not rare in the Danian sample (20265) from central Israel are similar with the original descriptions (10—14 μ).

Distribution: Common in the type Danian and equivalents in S.W. France, Tunisia, U. S. A. Recorded also from various Paleocene rocks (BRAMLETTE & MARTINI, 1964).

Zygodiscus spiralis BRAMLETTE & MARTINI

1964 *Zygodiscus spiralis* BRAMLETTE & MARTINI — Micropal., vol. 10, no. 3, p. 303, pl. 4, figs. 6—8.

Remarks: The strongly curved extinction lines along the margins distinguish this small species from others (Length 4—6 μ).

Distribution: Common in the Maastrichtian samples of Safad area (S-86, S-89, S-102, S-103, S-105). Known from the type Maastrichtian and equivalents in Denmark, S.W. France, Tunisia and the U.S.A.

Genus *Zygolithus* MATTHES, 1956

Zygolithus chelmiensis GORKA

(Pl. 1, figure 14)

1963 *Zygolithus chelmiensis* GORKA — Acta Pal. Polonica, vol. 8, p. 9, text-pl. 1, figs. 2—4.

Remarks: Our specimens show the same arrangement of the arcuate bars and the general appearance is similar to the original descriptions. It differs from *Z. diplogrammus* which has parallel bars. Length: 12—18 μ.

Distribution: Found in the Maastrichtian of the Negev (S-74). Known from the Campanian, Emscherian and upper Maastrichtian of Poland (GORKA, 1963).

Zygolithus concinnus MARTINI

(Pl. 2, figure 3; pl. 5, figure 12)

1961 *Zygolithus concinnus* MARTINI — Senckenberg. leth., vol. 42, p. 18, pl. 3, fig. 35; pl. 5, fig. 54.
1964 *Zygolithus concinnus* MARTINI — BRAMLETTE & MARTINI, Micropal., vol. 10, no. 3, p. 304, pl. 4, figs. 13—14.

Remarks and distribution: Small forms (dimensions: 5—12 μ) with the general appearance as described by MARTINI (1961) are encountered in the Danian sample (No. 20265) of Israel. Known from the Danian of Denmark and equivalents in the U.S.A. Originally described from the upper Paleocene of S.W. France; according to BRAMLETTE & MARTINI (1964) the Paleocene forms are generally larger than the Danian types.

Zygolithus crux (DEFLANDRE & FERT)

(Pl. 1, figure 1)

1952 *Discolithus crux* DEFLANDRE & FERT — C. R. Acad. Sci., vol. 234, p. 2101, fig. 8.
1954 *Discolithus crux* DEFLANDRE & FERT — DEFLANDRE & FERT, Ann. Pal., vol. 40, p. 143, pl. 14, fig. 4; text-fig. 55.
1961 *Zygolithus crux* (DEFLANDRE & FERT) — BRAMLETTE & SULLIVAN, Micropal., vol. 7, p. 149, pl. 6, figs. 8—10.
1963 *Zygolithus crux* (DEFLANDRE & FERT) — STRADNER, Sixth World Petr. Congress, Frankfurt, Sect. 1, paper 4, p. 9, pl. 4, figs. 6—7.
1964 *Zygolithus* cf. *Z. crux* (DEFLANDRE & FERT) — BRAMLETTE & MARTINI, Micropal., vol. 10, no. 3, p. 304, pl. 4, figs. 19—20.

Remarks: Though very small (Dimensions: (4—7 μ) our specimens are of the same appearance as described by the authors.

Distribution: Occurs in our Maastrichtian samples of Safad (S-89, S-102; S-103) and the Negev (Y. A. 74). Known in the type Maastrichtian and in equivalents in France, Tunisia, U. S. A. According to STRADNER (1963), this species occurs already from the Hauterivian.

Zygolithus diplogrammus DEFLANDRE

(Pl. 1, figures 11—13)

1954 *Zygolithus diplogrammus* DEFLANDRE — DEFLANDRE & FERT, Ann. Pal., vol. 40, p. 148, pl. 10, fig. 7; text-fig. 57.
1963 *Zygolithus diplogrammus* DEFLANDRE — GORKA, Acta Pal. Polonica, vol. 8, p. 8, text-fig. 1; pl. 1, fig. 1.
1964 *Zygolithus diplogrammus* DEFLANDRE — BRAMLETTE & MARTINI, Micropal., vol. 10, no. 3, p. 304, figs. 11—12.

Remarks: *Z. chelmiensis* GORKA, with the arcuate bars is related to the above species with its parallel bars. Some of our specimens have intermediate form between these two species.

Distribution: Occurs in the Maastrichtian samples of Safad area (S-86, S-89, S-102) and the Negev (Y. A. 74). Known from the type Maastrichtian and equivalents in France, Tunisia. U.S.A. (BRAMLETTE & MARTINI, 1964); upper Cretaceous of Poland (GORKA, 1963). Originally recorded from the Miocene-Pliocene (Sahelian) of N. Africa (DEFLANDRE & FERT, 1954). STRADNER (1963) regards the distribution of this species as Hauterivian-Campanian.

Genus *Eiffellithus* REINHARDT, 1965

Eiffellithus turriseiffeli (DEFLANDRE)

(Pl. 1, figure 17; pl. 5, figures 3 a, 3 b)

1954 *Zygolithus turriseiffeli* DEFLANDRE — DEFLANDRE & FERT, Ann. Pal., vol 40, p. 149, pl. 13, figs. 15—16; text-fig. 65.
1959 *Zygrhablithus turriseiffeli* (DEFLANDRE) — DEFLANDRE, Rev. Micropal., vol. 2, p. 135.
1964 *Zygrhablithus? turriseiffeli* (DEFLANDRE) — BRAMLETTE & MARTINI, Micropal., vol. 10, no. 3, p. 304, pl. 3, figs. 18—21; pl. 4, figs. 1—2.
1965 *Eiffellithus turriseiffeli* (DEFLANDRE) — REINHARDT, Monatsber. D. Akad. Wiss. Berlin, vol. 7, no. 1, p. 32.

Remarks and distribution: This typical form, especially when observed between cross nicols is analogous with the original descriptions. It occurs in most of the studied Maastrichtian samples (S-86, S-89, S-102, S-103, S-105, S-109, Y. A. 74, Y. A. 84) of Safad area and the Negev. Some reworked specimens are found also in the Danian and the upper Paleocene samples. This species is common in the type Maastrichtian and in equivalents in Denmark, France, Tunisia and the U. S. A. (BRAMLETTE & MARTINI, 1964).

FAMILY BRAARUDOSPHAERIDAE DEFLANDRE

Genus *Biantholithus* BRAMLETTE & MARTINI, 1964

Biantholithus aff. *B. sparsus* BRAMLETTE & MARTINI

(Pl. 5, figures 10 a, 10 b)

1964 *Biantholithus sparsus* BRAMLETTE & MARTINI — Micropal., vol. 10, no. 3, p. 305, pl. 4, figs. 21—25.
1964 *Biantholithus sparsus* BRAMLETTE & MARTINI — MARTINI, N. Jb. Geol. Paläont. Abh., vol. 121, no. 1, p. 50, pl. 7, figs. 1—2.

Remarks: Owing to overcalcification specimens it is difficult to discern the peripheral groove, but otherwise our forms, which occur in the Landenian (A. S. 229) of the Negev, are very similar to figure 25 (*B.* aff. *sparsus*) given by the authors. This species is known in the type Danian and equivalents in S.W. France and U. S. A.

Genus *Braarudosphaera* DEFLANDRE, 1947

Braarudosphaera bigelowi (GRAN & BRAARUD)

1935 *Pontosphaera bigelowi* GRAN & BRAARUD — Journ. Biol. Board Canada, vol. 1, p. 389, text-fig. 67.
1947 *Braarudosphaera bigelowi* (GRAN & BRAARUD) — DEFLANDRE, C. R. Acad. Sci., vol. 225, p. 439, text-figs. 1—5.
1954 *Braarudosphaera bigelowi* (GRAN & BRAARUD) — DEFLANDRE & FERT, Ann. Pal., vol. 40, p. 165, pl. 10, figs. 8—13; pl. 13, figs. 7—9.
1961 *Braarudosphaera bigelowi* (GRAN & BRAARUD) — BRAMLETTE & SULLIVAN, Micropal., vol. 7, p. 153, pl. 8, figs. 1; 2—5.

1961 *Braarudosphaera bigelowi* (GRAN & BRAARUD) — STRADNER & PAPP, Geol. Bundesanst., Wien, Jahrb., Sonderband 7, p. 116, pl. 37, figs. 1—3.
1964 *Braarudosphaera bigelowi* (GRAN & BRAARUD) — BRAMLETTE & MARTINI, Micropal., vol. 10, no. 3, p. 305.

Remarks and distribution: Very rare in the studied samples from Israel. Few specimens are encountered in the Maastrichtian sample (S-89) of Safad and the upper Paleocene (S-110) of the same area. According to different authors this species ranges from the Cretaceous to Recent.

FAMILY THORACOSPHAERIDAE KAMPTNER

Genus *Thoracosphaera* KAMPTNER, 1927

Thoracosphaera cf. *T. imperforata* KAMPTNER

(Pl. 1, figure 23)

1946 *Thoracosphaera imperforata* KAMPTNER — Österr. Akad. Wiss. Math.-Naturwiss., Kl., Anz., no. 11, p. 100.
1964 *Thoracosphaera* cf. *T. imperforata* KAMPTNER-BRAMLETTE & MARTINI, Micropal., vol. 10, no. 3, p. 305, pl. 5, figs. 1—2.

Remarks: Our specimens from the Maastrichtian are smaller than those of KAMPTNER and of BRAMLETTE & MARTINI, attaining only 8 to 10 μ in diameter, however, the spherical shell shows clearly, between cross nicols, the intricate arrangement of the small units and is similar especially to the descriptions of BRAMLETTE & MARTINI (1964). Our specimens differ from *T. deflandrei* by the intricate arrangement of the elements and by the smaller size. No opening was observed in the studied specimens.

Distribution: In the Maastrichtian of Safad area (S-89; S-102; S-103; S-105; S-109) and the Negev (Y. A. 84), in the Danian (No. 20265) and the Paleocene samples of the Negev (Y. A. 35; Y. A. 45).

Thoracosphaera cf. *T. deflandrei* KAMPTNER

(Pl. 5, figures 8 a, 8 b)

1956 *Thoracosphaera deflandrei* — KAMPTNER — Österr. Botan. Zeitschr., Bd. 103, H. 4, p. 448—456, figs. 1—4.
1963 *Thoracosphaera deflandrei* KAMPTNER — STRADNER (in: GOHRBANDT), Mitt. Geol. Ges., Wien, Bd. 56, no. 1, p. 78, pl. 10, figs. 9—10.

Remarks: Only broken fragments were found. In spite of the calcified elements, the original arrangement in some specimens is still discerned, showing the simple pentagonal or quadrangular elements. The simple structure and the size of the individual elements (1 μ) are similar to KAMPTNER's description (1956, fig. 3).

Distribution: Rare in the Danian sample (No. 20265) of central Israel. This species is known in the Mesozoic and the Tertiary.

INCERTAE SEDIS

Genus *Cylindralithus* BRAMLETTE & MARTINI, 1964

Cylindralithus cf. *C. serratus* BRAMLETTE & MARTINI

(Pl. 1, figure 21)

1964 *Cylindralithus serratus* BRAMLETTE & MARTINI — Micropal., vol. 10, no. 3, p. 310, pl. 5, figs. 18—20.

Remarks: Very small forms (diameter 3—7 μ) were found in the Maastrichtian samples, which are similar to the original descriptions, however, the basal delicate porous plate was not observed.

Distribution: Sparsely found in the Maastrichtian of Safad area (S-86) and the Negev (Y. A. 74 and Y. A. 84). Known from the lower Maastrichtian of Holland and equivalents in Tunisia and the U. S. A.

Genus *Lithraphidites* DEFLANDRE, 1963

Lithraphidites carniolensis DEFLANDRE

Pl. 5, figures 7 a, 7 b

1963 *Lithraphidites carniolensis* DEFLANDRE — C. R. Acad. Sci., vol. 256, p. 3486, figs. 1—8.

Remarks: Our specimens are usually thicker than those of DEFLANDRE, (Length 17 μ; thickness 2 μ), but are much more delicate and elongate than *L. quadratus* BRAMLETTE & MARTINI.

Distribution: Very typical in the Maastrichtian sample (Y. A. 74) of the Negev, and especially in the lower Maastrichtian sample (S-89) of Safad.

Genus *Lucianorhabdus* DEFLANDRE, 1959

Lucianorhabdus cayeuxi DEFLANDRE

1959 *Lucianorhabdus cayeuxi* DEFLANDRE — Rev. Micropal., vol. 2, p. 142, pl. 14, figs. 11—23.

1964 *Lucianorhabdus cayeuxi* DEFLANDRE — BRAMLETTE & MARTINI, Micropal., vol. 10, no. 3, p. 312, pl. 5, figs. 10—12.

Remarks: Few incomplete specimens show a comparatively wide interior canal and are similar to the descriptions of BRAMLETTE & MARTINI (ibid). The holotype and paratypes of DEFLANDRE (1959) have on the other hand much thinner openings, but this may be due to calcification and filling.

Distribution: Lower Maastrichtian of Safad area (S-89). According to BRAMLETTE & MARTINI (1964), this species which is widespread in most of the Senonian disappears at the end of the Lower Maastrichtian.

Genus *Marthasterites* Deflandre, 1959

Marthasterites bramlettei Brönnimann & Stradner

(Pl. 4, figure 7; pl. 6, figure 8)

1960 *Marthasterites bramlettei* Brönnimann & Stradner — Erdoelzeitschr., Jg. 76, no. 10, p. 366, figs. 17—20; 23—24.
1961 *Rhomboaster cuspis* Bramlette & Sullivan — Micropal., vol. 7, no. 2, p. 165-6, pl. 14, figs. 17—19.
1961 *Marthasterites bramlettei* Brönnimann & Stradner — Stradner & Papp, Geol. Bundesanst., Jahrb., Wien, Sonderband 7, p. 113, text-fig. 11/9 and 19/5.
1964 *Marthasterites bramlettei* Brönnimann & Stradner — Stradner, Erdoelzeitschr., no. 4, p. 5, fig. 31.

Remarks: The border lines of our specimens are more straight than in the original descriptions, thus resembling a low-bipyramidal body which has been shifted 60° upon the symmetry plane. Dimensions: 10—25 μ.

Distribution: In the Upper Paleocene (Landenian) Sample (A. S. 229) from the Negev, (in the *M. contortus* subzone). This species is known from Upper Paleocene rocks in Cuba (Brönnimann & Stradner, 1960); in California-Lodo Formation (Bramlette & Sullivan, 1961) and Switzerland (in the Schlierenflysch) where Hay (1961, 1962) reports its appearance in the *Marthasterites contortus* subzone, above the *Discoaster multiradiatus* subzone.

Marthasterites contortus (Stradner)

(Pl. 4, figure 8; pl. 6, figure 6)

1958 *Discoaster contortus* Stradner — Erdoelzeitschr., Jg. 74, no. 6, p. 187, figs. 35-6.
1959 *Discoaster contortus* Stradner — Fifth World Petrol. Congress, Sect. 1, paper 60, p. 1084, fig. 10.
1959 *Marthasterites contortus* (Stradner) — Deflandre, Rev. Micropal., vol. 2, no. 3, p. 139.
1961 *Marthasterites contortus* (Stradner) — Stradner & Papp, Geol. Bundesanst., Jahrb., Wien, Sonderband 7, p. 112, pl. 36, figs. 1—8.
1963 *Marthasterites contortus* (Stradner) — (in: Gohrbandt) Mitt. Geol. Ges., Wien, Band 56, no. 1, p. 80, pl. 11, figs. 11—13.

Remarks: Our sample shows variations in the form of this species and also different degrees of shifting upon the connecting plane, thus suggesting some relations with *M. bramlettei*.

Distribution: Found in the upper Paleocene (Landenian) sample of the Negev (A. S. 229) in the *M. contortus* subzone. This species is known in the upper Paleocene rocks of Austria (Stradner & Papp, 1961), in Cuba (Brönnimann & Stradner, 1960) and in Switzerland where Hay (1961, 1962) found it together with *Discoaster multiradiatus*. In the above works, Hay suggested a subdivision of *D. multiradiatus* zone into a lower — D. *multiradiatus* subzone devoid of *M. contortus* and a higher — *M. contortus* subzone in which is noted the first appearance of *M. contortus* and also *M. bramlettei*.

Marthasterites robustus (STRADNER)

(Pl. 4, figures 4—6; pl. 6, figures 7, 9)

1959 *Discoaster tribrachiatus robustus* STRADNER — Erdoelzeitschrift., Jg. 75, no. 12, p. 477, figs. 4—9.
1961 *Marthasterites robustus* (STRADNER) — STRADNER & PAPP, Geol. Bundesanst. Wien, Jahrb., Sonderband 7, p. 109, pl. 34, fgs. 6—8.

Remarks: Similar to *M. tribrachiatus* (BRAMLETTE & RIFDFL) but the latter is more delicate, the three arms are more elongate and are thinner. According to STRADNER (in STRADNER & PAPP, 1961) *M. robustus* is the direct forerunner of *M. tribrachiatus.*

Distribution: Occurs in the *M. contortus* subzone in the Landenian sample of the Negev (A. S. 229). Known from upper Paleocene rocks in Austria.

Genus *Microrhabdulus* DEFLANDRE, 1959

Microrhabdulus decoratus DEFLANDRE

(Pl. 5, figure 6 a)

1959 *Microrhabdulus decoratus* DEFLANDRE — Rev. Micropal., vol. 2, p. 140, pl. 4, figs. 1—5.
1964 *Microrhabdulus decoratus* DEFLANDRE — BRAMLETTE & MARTINI, Micropal., vol. 10, p. 314, pl. 6, figs. 1—2.

Distribution: Very typical in the Maastrichtian samples of Safad area S-86; S-89; S-96; S-102; S-105). Known in the lower Maastrichtian sediments of Holland and Tunisia, and from the Senonian of France, Poland, England and Australia. Originally recorded by DEFLANDRE (1959) from the Maastrichtian of France.

Microrhabdulus cf. *M. stradneri* BRAMLETTE & MARTINI

(Pl. 5, figure 6 b)

1964 *Microrhabdulus stradneri* BRAMLETTE & MARTINI — Micropal., vol. 10, no. 3, p. 316, pl. 6, figs. 3—4.

Remarks: This form is usually thicker than *M. decoratus*, bears straight striae along the walls and is truncated at the end. The alternate segments are intermediate in form between quadrangular and triangular. Dimensions: Length 20 μ; thickness 2 μ.

Distribution Common in the Maastrichtian samples of Safad (S-86; S-89; S-96; S-102; S-105; S-109). This species was reported by the authors from the type Maastrichtian and equivalents in Denmark, S. W. France, Tunisia, Alabama and Arkansas, U. S. A.

Genus *Micula* VEKSHINA, 1959

Micula staurophora (GARDET)

(Pl. 1, figure 19, 20)

1955 *Discoaster staurophorus* GARDET — Serv. Carte Geol. Algerie, Bull. 5, p. 534, pl. 10, fig. 96.
1959 *Trochoaster staurophorus* (GARDET) — STRADNER, Erdoelzeitschr. vol. 75, p. 480, textfigs. 49—50.
1960 *Nannotetraster staurophorus* (GARDET) — MARTINI & STRADNER, Erdoelzeitschr. vol. 76, p. 266, textfig. 1.
1961 *Nannotetraster staurophorus* (GARDET) — STRADNER & PAPP, Geol. Bundesanst. Wien, Jahrb. Sonderband 7, p. 101, pl. 31, figs. 2—4.
1963 *Micula staurophora* (GARDET) — STRADNER, Sixth World Petrol. Congress, Frankfurt, Sect. 1, paer 4, (preprint), p. 14, pl. 4, figs. 12 a—c.
1964 *Micula staurophora* (GARDET) — STRADNER, Erdoelzeitschr., no. 4 (April). p. 7, fig. 38.
1964 *Micula staurophora* (GARDET) — BRAMLETTE & MARTINI, Micropal., vol. 10, no. 3, p. 318, pl. 6, figs. 7—11.

Remarks: Many of our well preserved specimens resemble the descriptions of BRAMLETTE & MARTINI (1964) whereas others, which seem to be overcalcified are similar to those figured by STRADNER (in STRADNER & PAPP, 1961, pl. 31, figs. 2—3).

Distribution: Widespread in the Maastrichtian samples of Israel (S-86; S-89; S-96; S-102; S-103; S-105, Y. A. 74, Y. A. 84). Some were recorded in the Danian (No. 20265) and in the upper Paleocene (S-111; Y. A. 45).

Very common in the type Maastrichtian and equivalents in Europe, U. S. A., Australia, U. S. S. R. and the upper Cretaceous of many regions. STRADNER (1963) recognizes it as from the upper Turonian. Reworked specimens are often found in Tertiary sediments (MARTINI, 1961; BRAMLETTE & MARTINI, 1964).

Genus *Tetralithus* GARDET, 1955

Tetralithus gothicus DEFLANDRE forma *trifida* STRADNER

(Pl. 1, figure 22)

1963 *Tetralithus gothicus* DEFLANDRE form. *trifida* STRADNER — Sixth World Petrol. Congress, Frankfurt, Section 1, paper 4 (preprint), p. 14, pl. 6, fig. 2.

Remarks: One specimen so far was found. The general outlines are the same as described by the author, the only difference being the constricted tips at the end of the three arms. Dimensions: 12 μ.

Distribution: In the Maastrichtian sample No. Y. A. 74 from the Negev. The species *T. gothicus* DEFLANDRE (1959, p. 138) was described from the Maastrichtian of France.

Genus *Discoaster* Tan Sin Hok, 1927

Discoaster delicatus Bramlette & Sullivan

(Pl. 3, figures 10, 11)

1961 *Discoaster delicatus* Bramlette & Sullivan — Micropal., vol. 7, p. 159, pl. 11, fig. 3.
1964 *Discoaster delicatus* Bramlette & Sullivan — Sullivan, Univ. California Publ., Geol. Sci., vol. 44, p. 190, pl. 10, figs. 10—12.

Remarks: Very thin asteroliths with about 30—35 rays, however, some specimens especially from the *M. contortus* subzone may have only about 26 rays. Similar to *D. multiradiatus* from which it differs by the delicate ending of the rays, the raised central area which does not show the conjunction of the rays and by the smaller size. Diameter: 10—15 μ.
10—15 μ.

Distribution: Occurs in the upper Paleocene (Landenian) samples of Safad (S-111) and the Negev (Y. A. 35; A. S. 229).

Discoaster diastypus Bramlette & Sullivan

(Pl. 4, figure 3; pl. 6, figures 5, 12)

1961 *Discoaster diastypus* Bramlette & Sullivan — Micropal., vol. 7, p. 159, pl. 11, figs. 6—8.
1961 *Discoaster* aff. *D. diastypus* Bramlette & Sullivan — Micropal., vol. 7, p. 159, pl. 11, figs. 9—10.
1964 *Discoaster diastypus* Bramlette & Sullivan — Sullivan, Univ. California Publ., Geol. Sci., vol. 44, p. 190, pl. 10, figs. 3—4.

Remarks: Both plane and side views of our specimens are very similar to those described by the above authors, however, some variations in the arrangement and size of the stem occur. Diameter: 13—20 μ.

Distribution: Typical in the Upper Paleocene (Landenian) samples of Israel (S-111; Y. A. 35; Y. A. 45; A. S. 229), i. e. in the *D. multiradiatus* and in the *M. contortus* subzones.

Discoaster ehrenbergi Tan Sin Hok

(Pl. 4, figure 9)

1927 *Discoaster Ehrenbergi* Tan Sin Hok — Jaarb. Mijnwezen. Ned. Ind., p. 119, Text-fig. II, fig. 3.

Remarks: Few specimens with 9—11 rays which of all different descriptions resemble that figured by the author (Tan Sin Hok, 1927, fig. 3). Diameter: 15—20 μ.

Distribution: In the Upper Paleocene Sample Y. A. 35 from the Negev. Originally this form was described from the Isle of Rotti. (Moluccas).

Discoaster cf. D. gemmeus Stradner

(Pl. 6, figure 14)

1959 *Discoaster gemmeus* Stradner — Fifth World Petrol. Congress, Sect. 1, paper 60, p. 6, fig. 21.
1961 *Discoaster gemmeus* Stradner — Stradner & Papp, Geol. Bundesanst., Jahrb., Wien, Sonderbd. 7, p. 77, pl. 12, figs. 1, 2, 4, 8.
1963 *Discoaster gemmeus* Stradner — (in: Gohrbandt), Mitt. Geol. Ges., Wien, Bd. 56, Heft 1, p. 79, pl. 11, figs. 4, 5.

Remarks: Few badly preserved specimens shown similarities with the original characteristics: small thick asterolith with nine rays, united most of their length; an oblique view shows the high ridges along the rays and the thickening at the central area, however, because of the small size (diameter 5—6 μ) and the bad preservation exact specific determination could not be reached.

Distribution: In the Upper Paleocene sample S-110 from Safad area together with some other undeterminable discoasterids. *D. gemmeus* was described by Stradner (1959) from the Paleocene of Mattsee, Austria and from the Ilerdian (lower part of Zone E) of the Südhelvetikum north of Salzburg, Austria.

Discoaster multiradiatus Bramlette &Riedel

(Pl. 3, figures 1—9; pl. 4, figures 1, 2; pl. 6, figures 1—3, 11, 13)

1927 *Discoaster Ehrenbergi* Tan Sin Hok, pro parte — Jaarb. Mijnwezen. Ned. Ind., p. 119, Textfig. 2, fig. 2.
1954 *Discoaster multiradiatus* Bramlette & Riedel — Journ. Pal., vol. 28, no. 4, p. 396, pl. 38, fig. 10.
1959 *Discoaster multiradiatus* Bramlette & Riedel — Stradner, Fifth World Petrol. Congress, Sect. 1, paper 60, p. 2, fig. 1.
1961 *Discoaster multiradiatus* Bramlette & Riedel — Bramlette & Sullivan, Micropal., vol. 7, p. 161, pl. 12, fig. 10.
1961 *Discoaster multiradiatus* Bramlette & Riedel — Martini, Senck. leth. Bd. 42, no. 1, p. 9, pl. 2, fig. 19.
1961 *Discoaster multiradiatus* Bramlette & Riedel — Stradner & Papp, Geol. Bundesanst., Jahrb., Wien, Sonderbd. 7, p. 98, pl. 29, figs. 1—7.
1964 *Discoaster multiradiatus* Bramlette & Riedel — Sullivan, Univ. California Publ., Geol. Sci., vol. 44, no. 3, p. 191, pl. 10, figs. 8—9.

Remarks and distribution: Rosette-like asteroliths consisting usually of 18—26 rays joint throughout their length. However, some may consist of only 15 rays whereas others may reach 31 rays; the central area is depressed with or without a small knob or a stem.

This species is very typical in Paleocene sediments in many parts of the world (Cuba; Velasco shale-Mexico; Lodo Fm.-California; Anita shale-California: Schonisandstein of the Schlierenflysch-Switzerland; Zone E of the Südhelvetikum north of Salzburg, Austria; Gan in S. W. France; Waipawan stage- New Zealand, etc.). Most of these occurrences are now recognized as of upper Paleocene age. In result of these findings, a provisional *D. multiradiatus* zone was suggested by BRÖNNIMANN & STRADNER, 1960; HAY & SCHAUB, 1960; BRAMLETTE & SULLIVAN, 1961). Later, HAY (1961, 1962) subdivided the *D. multiradiatus* zone into a lower — *D. multiradiatus* subzone (devoid of *M. contortus*) and a higher — *M. contortus* subzone (which still contains *D. multiradiatus*) based on first appearance of *M. contortus* and *M. bramlettei.*

In Israel, *D. multiradiatus* is encountered in the upper Paleocene (Landenian) samples as follows:

Safad area — (S-111) —	*D. multiradiatus* subzone
Negev (Y. A. 35; Y. A. 45) —	*D. multiradiatus* subzone
Negev (A. S. 229) —	*M. contortus* subzone

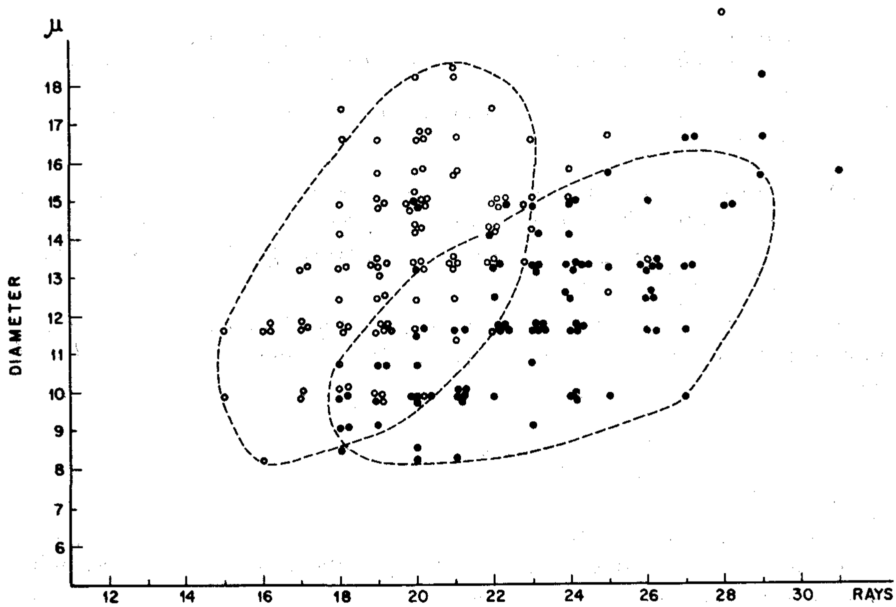


Fig. No. 5

STATISTICAL STUDY OF THE RELATIONS - DIAMETER / NUMBER OF RAYS - IN TWO DIFFERENT *DISCOASTER MULTIRADIATUS* POPULATIONS OF UPPER PALEOCENE (LANDENIAN) AGE.

o SPECIMENS FROM THE *M. CONTORTUS* SUBZONE (A. S. 229)
• SPECIMENS FROM THE *D. MULTIRADIATUS* SUBZONE (S. 111)

A small statistical study of the different *D. multiradiatus* communities in these subzones was carried out. About one hundred individuals from each subzone were treated. Their size and number of rays are shown in Fig. no. 5. Owing to its better preservation, sample S-111 from Safad was chosen to represent the lower — *D. multiradiatus* subzone in comparison with sample A. S. 229 of the higher — *M. contortus* subzone. Results indicate that in the studied areas, the majority of the *D. multiradiatus* individuals with a diameter of 12—15 μ have:

in the *M. contortus* subzone — from 18 to 22 rays, and
in the *D. multiradiatus* subzone — from 22 to 26 rays.

Furthermore, brief checking of sample Y. A. 35 also from the *D. multiradiatus* subzone has shown the same general conclusions. This mean reduction in the number of the rays may possibly express some evolutionary trend within this species, however, ecological reasons must not be excluded as well at this stage of investigation.

Discoaster ornatus STRADNER

(Pl. 3, figures 12—15; pl. 6, figure 4)

1958 *Discoaster ornatus* STRADNER — Erdoelzeitschr., no. 6, p. 188, fig. 38.
1959 *Discoaster ornatus* STRADNER — Fifth World Petrol. Congress, Sect. 1, paper 60, p. 8, fig. 30.
1961 *Discoaster ornatus* STRADNER — STRADNER & PAPP, Geol. Bundesanst., Jahrb. Wien, Sonderband 7, p. 64, pl. 2, figs. 1—6.

Remarks: Many of our specimens resemble the original description and especially that figured by STRADNER & PAPP (1961, pl. 2, fig. 5—6). As also here, no pores were ever distinguished at the distal part of the rays. Diameter: 15—25 μ.

Distribution: Typical in the upper Paleocene (Landenian) samples of Israel (S-111; Y. A. 35; A. S. 229). Known in the Paleocene of Austria.

Discoaster sp. 1

(Pl. 6, figure 15)

Description: Asterolith with eight short and pointed rays joint at a distance of about one third from the periphery; the central area with an uneven surface bears a small knob.

Remarks and distribution: This badly preserved specimen occurs in sample S-110 from the upper Paleocene of Safad.

Discoaster sp. 2

Remarks and distribution: Incomplete specimen of a discoaster with about 12 rays. Diameter about 10—12 μ, found in the upper Paleocene sample (S-110) of Safad area. The reason of including here some badly preserved and insufficiently studied discoasters is on the first place to show their presence in the above sample which formerly was regarded as belonging to the upper Maastrichtian.

Genus *Fasciculithus* Bramlette & Sullivan, 1961

Fasciculithus involutus Bramlette & Sullivan

(Pl. 5, figures 14, 15)

1961 *Fasciculithus involutus* Bramlette & Sullivan — Micropal., vol. 7, p. 164, pl. 14, figs. 1—5.
1963 *Fasciculithus involutus* Bramlette & Sullivan — Stradner (in Gohrbandt) Mitt. Geol. Ges. Wien, Bd. 56, no. 1, p. 79, pl. 10, figs. 14—15.
1964 *Fasciculithus involutus* Bramlette & Sullivan — Sullivan, Univ. California Publ. Geol. Sci., vol. 44, p. 193, pl. 12, figs. 9 a—b.

Remarks: Many specimens are very similar to the original descriptions but have a shorter cylinder. Dimensions: Diameter 5 μ; length 4,5 μ.

Distribution: Very typical in the upper Paleocene (Landenian) samples of Safad area (S-111) and the Negev (Y. A. 35; Y. A. 45); in contrast of their association in the *D. multiradiatus* subzone, these forms are lacking in sample A. S. 229 of the higher — *M. contortus* subzone from the Negev. Similar, unidentified forms when observed between cross nicols, are at first mistaken for *F. involutus*, but a close exmamination shows that they are rounded, not cylindrical and are smaller.

Distribution: *F. involutus* is common in the Paleocene rocks of many regions including France; England (Thanetian); Austria (Zone D of the Südhelvetikum north of Salzburg) and the U. S. A. (Units 1 and 2 of the Lodo Formation).

Genus *Heliolithus* Bramlette & Sullivan, 1961

Heliolithus riedeli Bramlette & Sullivan

(Pl. 6, figures 10 a, 10 b)

1961 *Heliolithus riedeli* Bramlette & Sullivan — Micropal., vol. 7, p. 164, pl. 14, figs. 9—11.
1963 *Heliolithus riedeli* Bramlette & Sullivan — Stradner (in: Gohrbandt) Mitt. Geol. Ges. Wien, Bd. 56, p. 78, pl. 10, figs. 11—13.
1964 *Heliolithus riedeli* Bramlette & Sullivan — Sullivan, Univ. California Publ. Geol. Sci. vol. 44, p. 193, pl. 12, figs. 4 a—b; 6 a—b; 7 a—b; 8 a—b.

Remarks and distribution: Few specimens only were found in sample S-111 of the Landenian from the Safad area. According to the authors *H. riedeli* is widespread in various Paleocene localities of England, France, Mexico and the U. S. A. Stradner (in: Gohrbandt, 1963) reports its presence in zone E of the Südhelvetikum in Austria (Ilerdian).

Distribution of Coccolithophorids and related Nannoplankton recorded in the Maastrichtian-Danian-Paleocene sediments in some parts of Israel.

Species:															
Stage	Maastrichtian									Danian	Paleocene				
Substage											Landenian				
Biostratigraphic zone												*D. multiradiatus* zone (s. l.)			
Biostratigraphic subzone												*D. multiradiatus* (s. s.)			*M. contortus*
Sample no.	S-86	S-89	S-96	S-102	S-103	S-105	S-109	YA 74	YA 84	20265	S-110	S-111	YA 35	YA 45	AS 229
1. *Arkhangelskiella cymbiformis*	x	x	x	x	x	x	x	x	x						
2. *Coccolithus* cf. *C. barnesae*	x	x	x	x	x	x	x	x							
3. *C. bidens*												x	x		
4. *C. crassus*										x	x	x		x	x
5. *C. danicus*										x					
6. *C. helis*										x					
7. *Cretarhabdus decorus*				x					x						
8. *Deflandrius intercisus*	x					x		x	x						
9. *Discolithina* cf. *D. numerosa*	x	x	x	x	x	x	x	x	x						
10. *Parhabdolithus embergeri*			x					x							
11. *Kamptnerius magnificus*								x							
12. *Zygodiscus? amphipons*					x	x		x							
13. *Z. sigmoides*										x					
14. *Z. spiralis*	x	x		x	x	x									
15. *Zygolithus chelmiensis*								x							

16. *Z. concinnus*										x					
17. *Z. crux*		x		x	x			x							
18. *Z. diplogrammus*	x	x		x				x							
19. *Eiffellithus turriseiffeli*	x	x		x	x	x	x	x	x						
20. *Biantholithus* aff. *B. sparsus*															x
21. *Braarudosphaera bigelowi*		x									x				
22. *Thoracosphaea* cf. *T. imperforata*		x		x	x	x	x		x	x			x	x	
23. *T.* cf. *T. deflandrei*										x					
24. *Cylindralithus* cf. *C. serratus*	x							x	x						
25. *Lithraphidites carniolensis*		x						x							
26. *Lucianorhabdus cayeuxi*		x													
27. *Marthasterites bramlettei*															x
28. *M. contortus*															x
29. *M. robustus*															x
30. *Microrhabdulus decoratus*	x	x	x	x		x									
31. *M.* cf. *M. stradneri*	x	x	x	x		x	x								
32. *Micula staurophora*	x	x	x	x	x	x		x	x						
33. *Tetralithus gothicus* forma *trifida*								x							
34. *Discoaster delicatus*												x	x		x
35. *D. diastypus*												x	x	x	x
36. *D. ehrenbergi*													x		
37. *D.* cf. *D. gemmeus*											x				
38. *D. multiradiatus*												x	x	x	x
39. *D. ornatus*												x	x		x
40. *D.* sp. 1											x				
41. *D.* sp. 2											x				
42. *Fasciculithus involutus*												x	x	x	
43. *Heliolithus riedeli*												x			

Chart No. 1

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PLATE 1

Nannofossils from the Maastrichtian beds

Figs.	
1	*Zygolithus crux* (Deflandre & Fert) Nahal Zin, the Negev, sample Y. A. 74.
2, 2a, 3—5	*Discolithina* cf. *D. numerosa* (Gorka) (2) normal light; (2 a) x-nic. Nahal Zin, the Negev, sample Y. A. 74; (3) x-nic. Safad area, sample S-102; (4) normal light. Safad area, sample S-109; (5) normal light. Nahal Zin, the Negev, sample Y. A. 74.
6, 6a, 7—8	*Arkhangelskiella cymbiformis* Vekshina (6) normal light; (6 a) x-nic. Nahal Zin, the Negev, sample Y. A. 74; (7) Safad area, sample S-103; (8) Nahal Zin, sample Y. A. 84.
9—10	*Zygodiscus? amphipons* Bramlette & Martini Nahal Zin, the Negev, sample Y. A. 74.
11—13	*Zygolithus diplogrammus* Deflandre (11) Safad area, sample S-102; (12) Nahal Zin, the Negev, sample Y. A. (13) Safad area, sample S-89.
14	*Z. chelmiensis* Gorka Nahal Zin, the Negev, sample Y. A. 74.
15—16	*Parhabdolithus embergeri* (Noël) (15) Nahal Zin, the Negev, sample Y. A. 74; (16) Safad area, sample S-96.
17	*Eiffellithus turriseiffeli* (Deflandre) Nahal Zin, the Negev, sample Y. A. 84.
18	*Deflandrius intercisus* (Deflandre) Safad area, sample S-105.
19—20	*Micula staurophora* (Gardet) (19) Plan view; (20) Side view. Safad area, sample S-105.
21	*Cylindralithus* cf. *C. serratus* Bramlette & Martini Nahal Zin, the Negev, sample Y. A. 74.
22	*Tetralithus gothicus* Deflandre forma trifida Stradner Nahal Zin, the Negev, sample Y. A. 74.
23	*Thoracosphaera* cf. *T. imperforata* Kamptner x-nic. Nahal Zin, the Negev, sample Y. A. 84.

PLATE 1

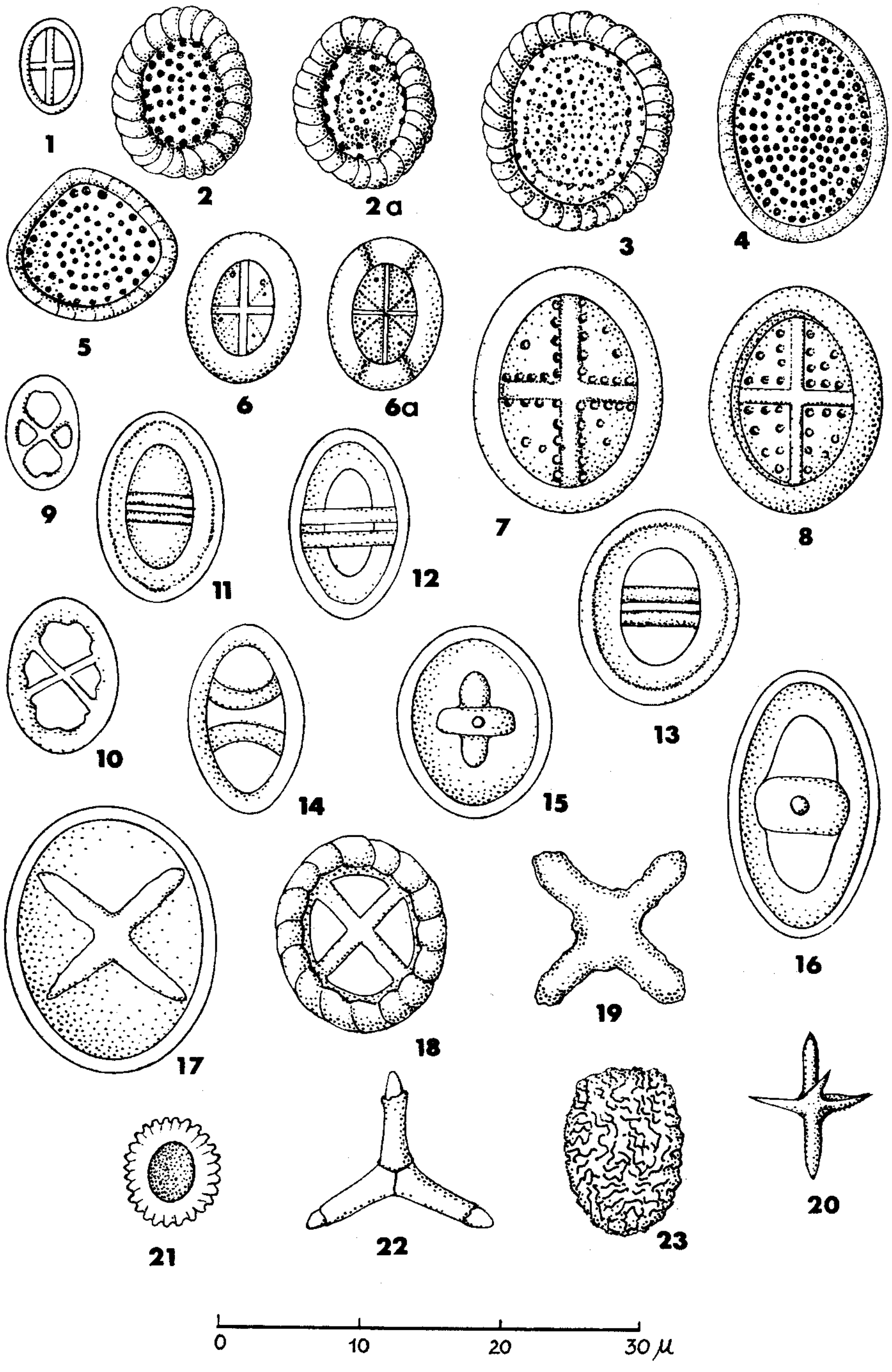

PLATE 2

Nannofossils from the Danian sample 20265, Jerusalem—Tel-Aviv Road, Central Israel (except fig. 4)

Figs.	
1	*Coccolithus helis* STRADNER
2	*C. danicus* (BROTZEN)
3	*Zygolithus concinnus* MARTINI
4	*Coccolithus bidens* BRAMLETTE & SULLIVAN, Safad area, sample S-111 (Landenian)
5	*Zygodiscus sigmoides* BRAMLETTE & SULLIVAN

PLATE 2

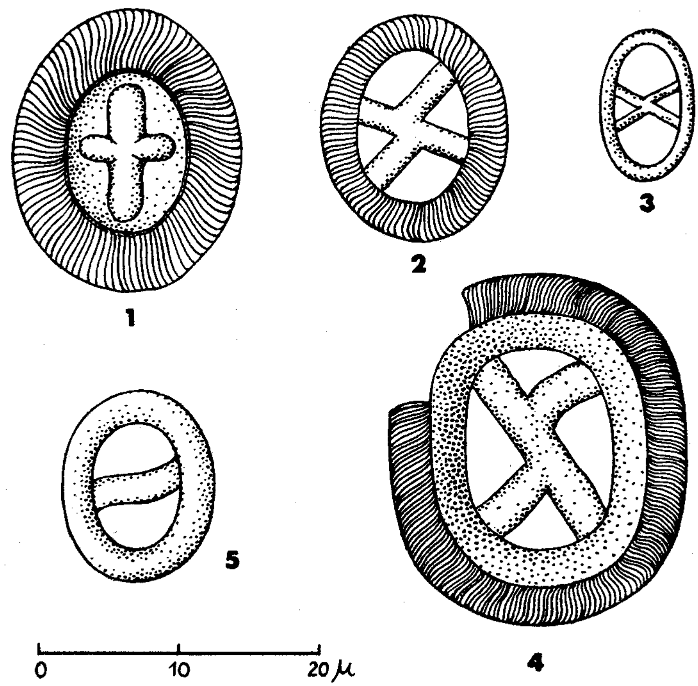

PLATE 3

Nannofossils from the Landenian beds (*D. multiradiatus* subzone)

Figs.

1—9 *Discoaster multiradiatus* Bramlette & Riedel
(1) asterolith with 28 rays, Safad area, sample S-111; (2) asterolith with 26 rays, Nahal Zin, the Negev, sample Y. A. 35; (3) asterolith with 21 rays, Safad area, sample S-111; (4) asterolith with 17 rays, Nahal Zin, the Negev, sample Y. A. 45; (5) asterolith with 21 rays, Nahal Zin, the Negev, sample Y. A. 35; (6) asterolith with 18 rays, Nahal Zin, the Negev, sample Y. A. 35; (7—9) side view. Specimens from Nahal Zin, the Negev, sample Y. A. 35.

10—11 *D. delicatus* Bramlette & Sullivan
(10) asterolith with 26 rays; (11) asterolith with 29 rays. Nahal Zin, the Negev, sample Y. A. 35.

12—15 *D. ornatus* Stradner
(12) asterolith with 10 rays; (13) asterolith with 9 rays. Nahal Zin, the Negev, sample Y. A. 35; (14) asterolith with 10 rays; (15) asterolith with 8 rays. Safad area, sample S-111.

PLATE 3

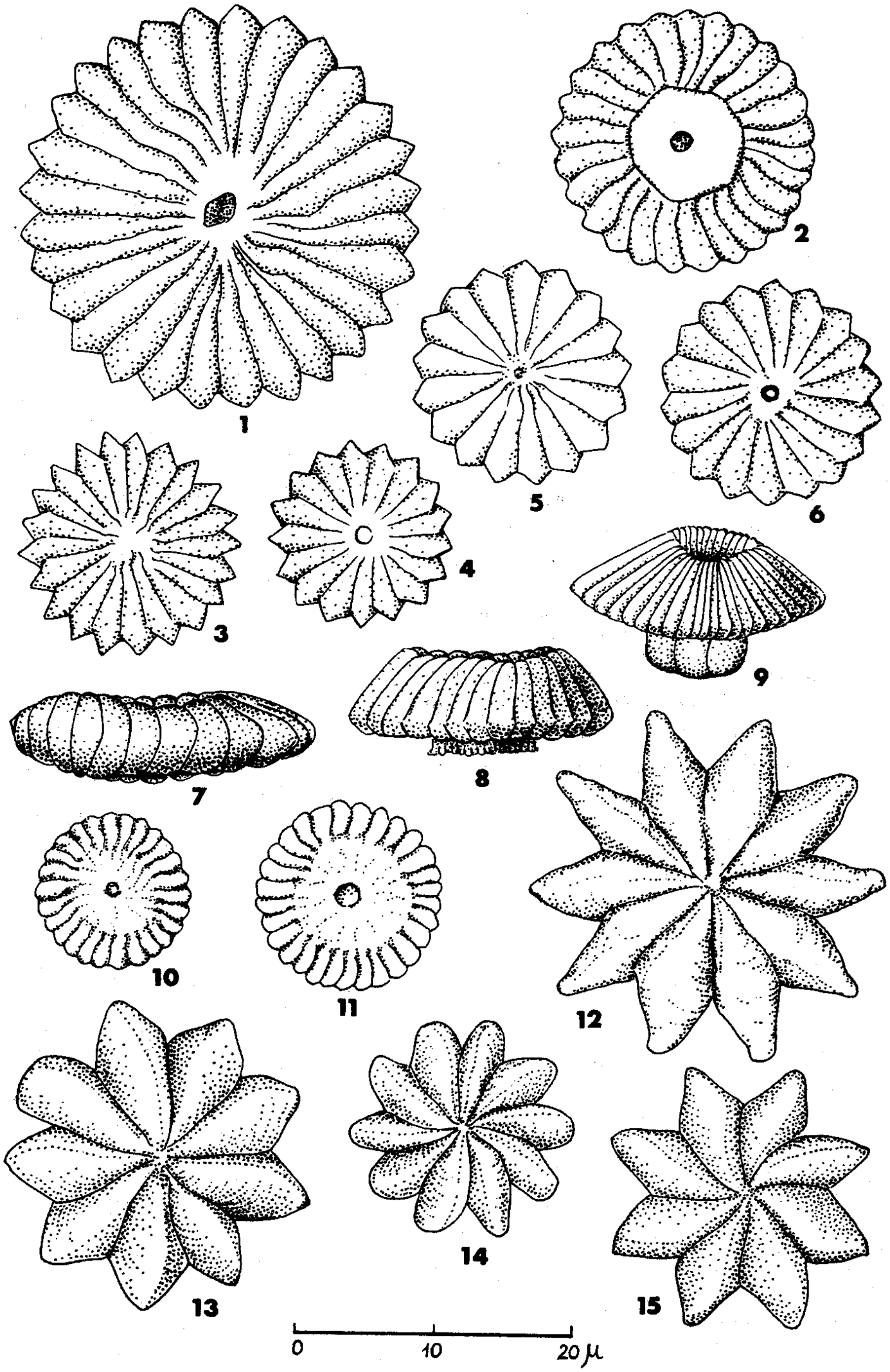

PLATE 4

Nannofossils from the Landenian beds

Figs.	
1—8	Nahal Atadim, the Negev, sample A. S. 229 (*M. contortus* subzone)
9	Nahal Zin, the Negev, sample Y. A. 35 (*D. multiradiatus* subzone)
1—2	*Discoaster multiradiatus* BRAMLETTE & RIEDEL (1) asterolith with 24 rays; (2) asterolith with 18 rays.
3	*D. diastypus* BRAMLETTE & SULLIVAN asterolith with 13 rays
4—6	*Marthasterites robustus* (STRADNER)
7	*M. bramlettei* BRÖNNIMANN & STRADNER
8	*M. contortus* (STRADNER)
9	*Discoaster ehrenbergi* TAN SIN HOK

PLATE 4

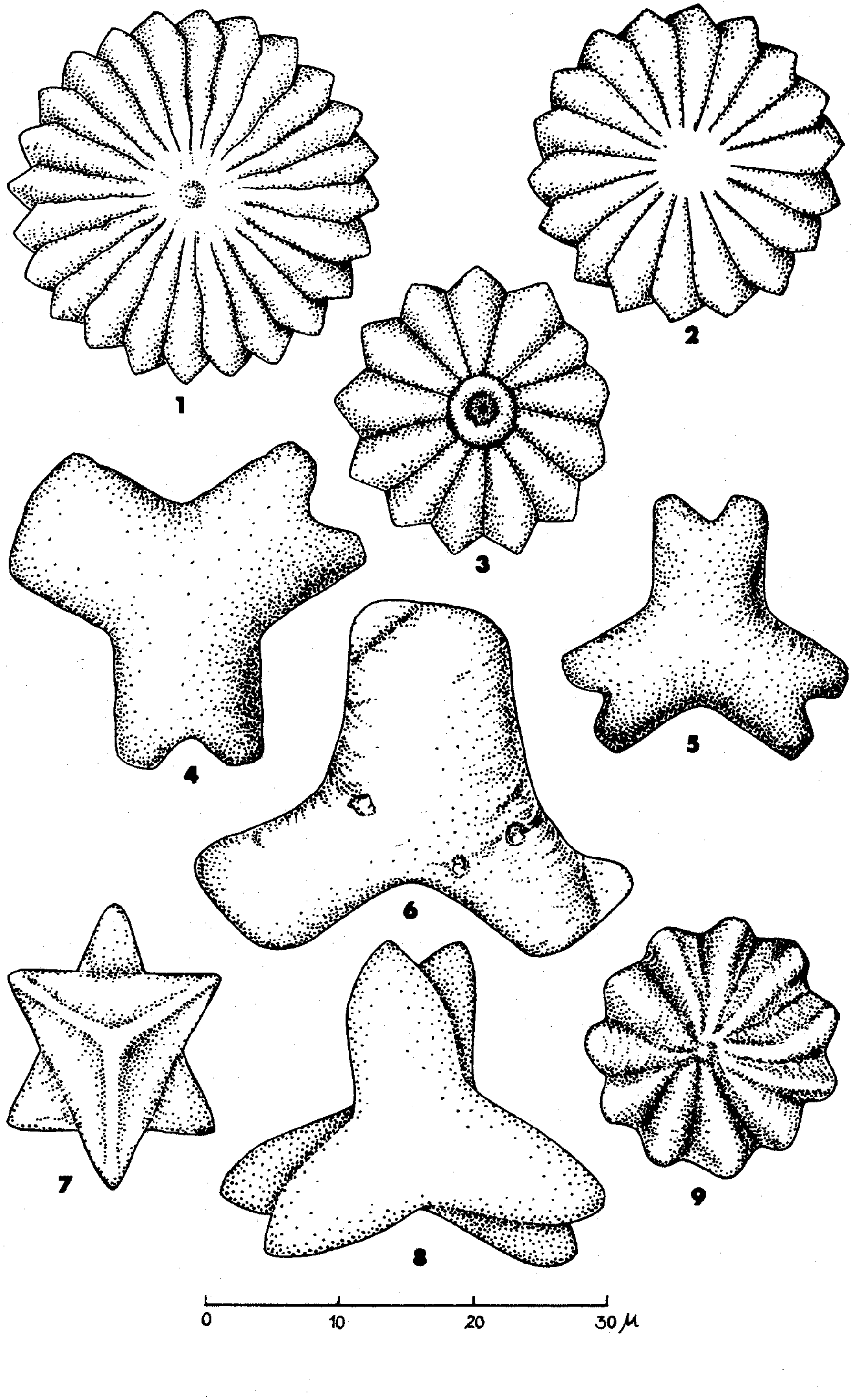

PLATE 5

Figs.

1, 2 a, b *Arkhangelskiella cymbiformis* Vekshina
1-x-nic.; 2a-normal light; 2 b-x-nic. Nahal Zin, the Negev, sample Y. A. 84 (Maastrichtian).

3 a, b *Eiffellithus turriseiffeli* (Deflandre)
3 a-normal light; 3 b-x-nic. Nahal Zin, the Negev, sample Y. A. 84 (Maastrichtian).

4 *Discolithina* cf. D. *numerosa* (Gorka)
normal light, Safad area, sample S-109 (Maastrichtian).

5 *Kamptnerius magnificus* Deflandre
x-nic. Nahal Zin, the Negev, sample Y. A. 74 (Maastrichtian).

6 a *Microrhabdulus decoratus* Deflandre
x-nic. Safad area, sample S-102 (Maastrichtian).

6 b *M.* cf. *M. stradneri* Bramlette & Martini
x-nic. Safad area, sample S-102 (Maastrichtian).

7 a, b *Lithraphidites carniolensis* Deflandre
7 a-x-nic.; 7 b-normal light. Nahal Zin, the Negev, sample Y. A. 74 (Maastrichtian).

8 a, b *Thoracosphaera* cf. *T. deflandrei* Kamptner
8 a-normal light; 8 b-x-nic. Jerusalem—Tel-Aviv-Road, sample 20265 (Danian).

9 a, b *Coccolithus crassus* Bramlette & Sullivan
9 a-normal light; 9 b-x-nic. Nahal Zin, the Negev, sample Y. A. 45 (Landenian).

10 a, b *Biantholithus* aff. *B. sparsus* Bramlette & Martini
10 a-normal light; 10 b-x-nic. Nahal Atadim, the Negeve, sample A. S. 229 (Landenian).

11 *Coccolithus helis* Stradner
x-nic. Jerusalem—Tel-Aviv Road, sample 20265 (Danian).

12 *Zygolithus concinnus* Martini
x-nic. Jerusalem—Tel-Aviv Road, sample 20265 (Danian).

13 *Coccolithus bidens* Bramlette & Sullivan
normal light, Safad area, sample S-111 (Landenian).

14—15 *Fasciculithus involutus* Brameltte & Sullivan
14-plan view, x-nic.; 15-side view, x-nic. Safad area, sample S-111 (Landenian).

PLATE 5

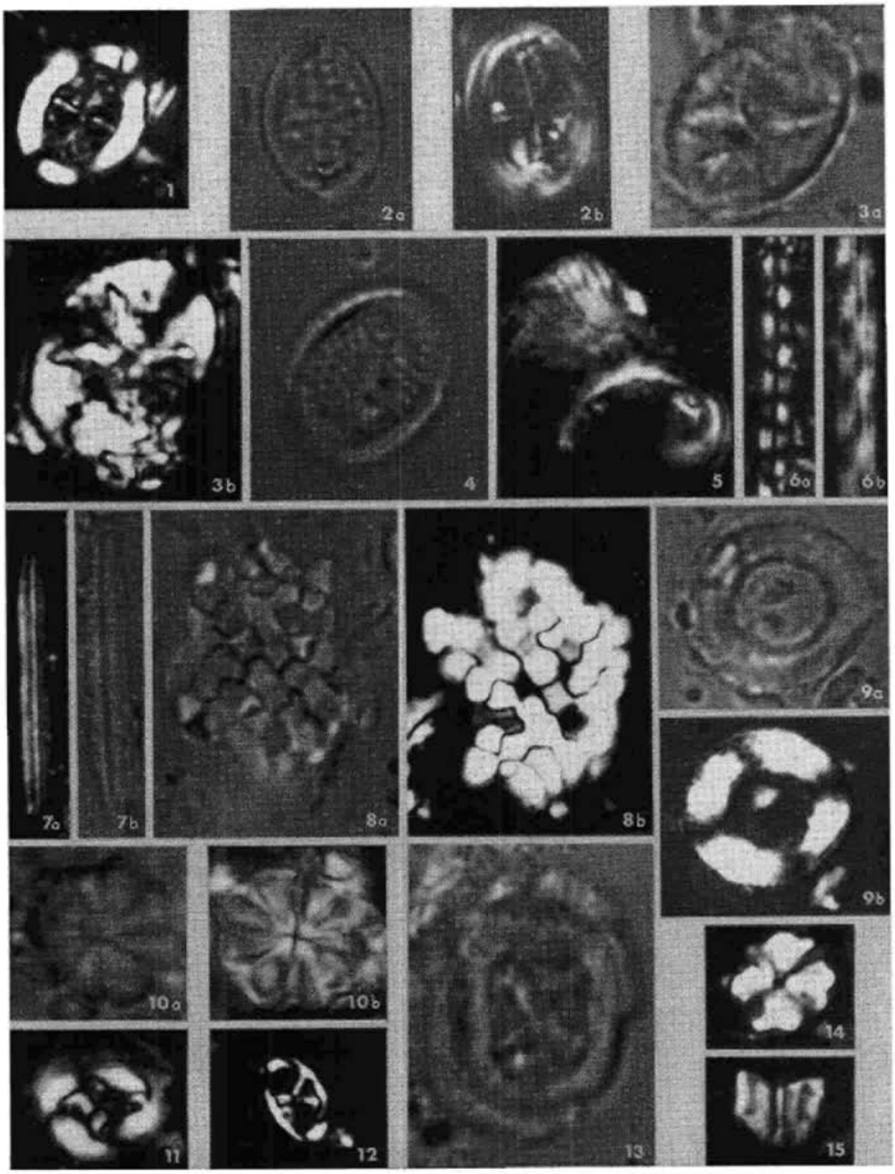

PLATE 6

Nannofossils from the Landenian beds

Figs.	
1, 10 a, b,	Safad area, sample S-111 (*D. multiradiatus* subzone).
11	Safad area, sample S-110 (Landenian undivided).
14, 15	Nahal Atadim, the Negev, sample A. S. 229 (*M. contortus* subzone).
1—3	*Discoaster multiradiatus* BRAMLETTE & RIEDEL 1-asterolith with 29 rays; 2-asterolith with 20 rays; 3-asterolith with 17 rays.
4	*D. ornatus* STRADNER
5	*D. diastypus* BRAMLETTE & SULLIVAN
6	*Marthasterites contortus* (STRADNER)
7	*M. robustus* (STRADNER)
8	*M. bramlettei* BRÖNNIMANN & STRADNER
9	*M. robustus* (STRADNER) side view.
10 a, b	*Heliolithus riedeli* BRAMLETTE & SULLIVAN 10 a-normal light; 10 b-x-nic.
11	*Discoaster multiradiatus* BRAMLETTE & RIEDEL side view.
12	*D. diastypus* BRAMLETTE & SULLIVAN side view.
13	*D. multiradiatus* BRAMLETTE & RIEDEL side view.
14	*D.* cf. *D. gemmeus* STRADNER oblique view.
15	*Discoaster* sp. 1

PLATE 6